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MEMORIAL HALL: THE EFFICACY OF GEOGRAPHIC INFORMATION SYSTEM SOFTWARE IN CONSERVATION AND MAINTENANCE

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CHAPTER 1 – INTRODUCTION

GIS has recently acquired much attention in the study of cultural resource management. Most reports documenting the use of a GIS (geographic information systems) have been favorable, due in large part to the strong analytical and data management capabilities of a GIS. However, there have been few published case studies that discuss the merits and benefits of using a GIS to analyze condition. This thesis will examine the more specific use of a GIS to complete a condition survey that is comprised of distinct units, such as tiles in a floor or the stones of a building façade.

The floor of Memorial Hall, in Fairmount Park, Philadelphia (**Figures 1.1, 1.2 and 1.3**), is the test area chosen to determine the efficacy of GIS for conservation and maintenance projects. This floor was chosen as a test area for several reasons – it is composed of discreet units that would enable the creation of a database where each stone has one record, the floor in the Great Hall is an ideal candidate because the condition is in severe need of assessment, and there is no funding in place to complete this, and The Fairmount Park Commission currently has GIS software (*Esri's ArcView*) and a GIS mapping program in place. All of these factors make this an ideal situation to test the efficacy of GIS for condition assessments.

A recent estimate for work on Memorial Hall, which only included the repair of all roofing and the conservation of the Great Hall and adjacent spaces, has been

completed, with a total cost estimate of $11 million.[1] The problem of water infiltration has caused severe deterioration of the interior features, including the floor and the decorative plaster (**figure 1.4**). From the outset of this project, it is important to note that the floor is only one feature of this building. No matter the significance, if the structure is not stable, the floor will also ultimately fail. The entire building is in need of intervention, with the roof having the highest priority. Even without a full-scale intervention on the building, this thesis will give guidelines for improving the condition of the floor through appropriate maintenance, thereby reducing the damage caused by inappropriate intervention (**figure 1.5**). Although this in itself will not "restore" the floor, it will slow or halt the deterioration. As funds and labor become available, the same maintenance guidelines can be applied to the full-scale intervention of the floor. The entire building has suffered over a century's worth of deterioration and deferred maintenance. Its function has changed from an art museum to municipal government offices, a research center and special events facility. For over one hundred years, repair attempts have employed various inappropriate materials and methods, destroying the unity and threatening the lifespan of the original floor.

A literature review pertaining to the issues surrounding this thesis has been completed. The limited amount of literature discussing the conservation of historic masonry floors was examined. Most of the extant literature on flooring has neglected the

[1] Correspondence to John Donnelly from LF Driscoll Co. to John Bingswanger. From Fairmount Park

conservation issues surrounding buildings that sustain heavy, everyday usage. Most of the published discussion focuses on European ecclesiastical floors that have had, in one form or another, some protection from everyday functions. However, the philosophical approach and conservation methods for religious structures can be applied to civic monumental sites. Because the conservation needs of building types and spaces vary drastically with different uses, more research needs to be completed. The Great Hall, which is used for large lectures, fundraising events and entertainment venues, must be treated differently from a large Cathedral that can better control the movement of scores of tourists, furniture and equipment. Recent publications on the use of GIS in cultural resource management were surveyed for the purpose of this thesis. In order to contextualize the work of this project, a brief history of Memorial Hall is summarized, focusing largely on construction, materials and use patterns.

The methodology used to create the conditions survey to document each tile, base drawings and GIS project are described. The parameters and guidelines used in the analytical phase are discussed and the results are summarized. This will allow for this project to act as a prototype for the development of a methodology for conservation and maintenance utilizing GIS, especially for properties in Fairmount Park.

The ultimate goal of this project is to develop a system that will have the capacity to be used throughout all phases of the conservation plan. It will be the tool for analyzing

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Archives in the "Memorial Hall" folder, dated April 21, 2000.

the condition, allow for the prioritization of treatments as funding becomes available and function as the repository for the documentation of future repairs.

CHAPTER 2 – METHODOLOGY

The goal of this thesis is to document the condition, develop treatment recommendations and design a maintenance plan for the floor in Memorial Hall. The documentation phase was composed of two surveys – a stone by stone condition survey that recorded the condition and treatment recommendations of each tile, and a mortar condition survey that graphically documented the condition of every mortar joint. The stone tile condition survey was recorded in a database so the information can be queried, and then presented graphically. Because the different conditions present in the mortar were limited, a graphic representation was more than adequate.

Survey Process

A survey form was designed to investigate the condition of each tile (**see appendix A**). Four primary categories were addressed – the initial design and construction techniques, the inherent properties of the stone, the physical environment, and past repairs and maintenance. Because the goal of this survey is to create a conservation and maintenance plan, the physical environment and past treatments were the primary focus – these are the factors that have the potential to be altered and are the overwhelming cause of the deterioration. The initial design and construction process is treated generally throughout the floor, since it was created as one unit utilizing the same

technology (see chapter 4). The inherent properties of the stone is discussed by type, but not examined in great depth at the level of this survey.

The stone tile survey form carefully documents the current condition of the stones due to environmental and maintenance factors. The information gathered will be divided into increasingly specific branches by Boolean values, creating a network of general conditions funneled down to very specific conditions (**figure 2.1**). For example, in order to determine the appropriateness of a replacement material, the form asks first if the stone is a replacement. If it is, the next question is the appropriateness of the replacement. If it is appropriate, this branch is complete, but if not, it is described and treatments are recommended.

The form was designed to gather information that will both intelligently guide the treatment recommendations and document the conditions that can be altered by changing the environmental conditions and maintenance patterns. First, each stone was visually examined, looking at the amount of cracking and the resulting number of individual fragments, abrasion, discoloration, the soundness of the bedding mortar, pitting and the number of corners above, below or even with the plane of the floor. In addition to documenting condition, treatment recommendations were made. Finally, each stone was examined for past repairs or replacement, the appropriateness of each was determined, and treatments were recommended.

Knowing early on in the survey design process that the results of the survey had to be input in a database in a format that would be readable by *Esri's ArcView* GIS, all values for the survey form were recorded as numeric values. A key to all of the values in the survey is included in (**appendix B**).

In order to create guidelines so the condition survey can be completed on the rest of the floor after this thesis has been completed on the test area, all terms used to document the floor must be carefully defined. The first section of the form determines the integrity of the tiles – whether it is a replacement or partial replacement (partial replacement is recorded as a percentage replaced of total original). An inappropriate replacement may be any material that does not match the original in stone type, size and shape (**figures 2.2 and 2.3**). If the replacement is appropriate, it should not detract from the overall composition, rhythm and pattern of the floor, and although the material may not be an exact match to the original, it has similar material properties and a similar appearance (**figure 2.4**). For example, it is inappropriate to replace stone with a portland cement or asphalt infill (**Figure 2.5**). Although this can be matched to the stone in appearance, the material properties of the cement are inappropriate and will likely damage the surrounding stone and visual unity. The goal of this section is to determine the amount of original fabric, and to replace all inappropriate fabric with a stone that will renew the visual unity and be sympathetic to the existing conditions.

All repairs to the original tile must be recorded. Filling cracks with an inappropriate material has been a common repair (**figure 2.6**). Tiles have also been improperly reset in a cementitous bed of mortar, out of plane from the rest of the floor. This indicates that the stone was once loose and was repaired by removing the stone, putting down a new coat of bedding mortar directly on the old, and resetting the tile without leveling it. This type of repair has been standard in the history of the floor. Appropriate repairs do not impair the visual unity of the floor, have similar material properties, and do not compromise the integrity of the floor.

The presence and severity of cracking (**figure 2.7**) in each tile needs to be recorded because it is indicative of several potential problems increasing the deterioration of the floor. The cracking can result from the current uses of the Great Hall that require large and heavy equipment to be dragged across the unstable surfaces of the floor, the rainwater that puddles on the floor and saturates the bedding mortar, poorly designed original dimensions, inadequate construction techniques, structural shifting and past repairs with inappropriate materials. If there is any cracking in the tile, it should be indicated on the survey form, including cracks that have not propagated throughout the stone, where the tile is still in one piece. The number of pieces each tile has been fractured into need to be recorded because it will indicate the severity of the cracking.

The number of corners above, below and even with the plane of the floor can be indicative of past repairs (**figure 2.8**), bedding mortar failure (**figures 2.9 and 2.10**) and

structural shifting. These areas need treatment because they present a hazard to the users of the space and the out of plane sections are particularly vulnerable to chipped corners. In areas with multiple displacements, it is difficult to determine the original level of the floor. In this situation, the closest, unaltered area was used as a benchmark to make a qualitative judgment on the amount of displacement.

Tiles may also exhibit partial loss, which is recorded as a percentage of the total original (**figure 2.11**). Not all losses should be recorded as partial loss – if the patch or mortar infill between two fragments exceeds ½ inch in width (or perpendicular to the fracture), it is considered a partial loss, a partial replacement and a partial repair. However, if the area in question does not exceed ½ inch in width, it can be recorded as a repair and partial loss.

Pitting primarily affects the breccias in the floor of Memorial Hall, due to the stone type's inherent heterogeneity **(figure 2.12).** It is defined as the loss of stone material from the surface of the tile, especially following natural variation in the composition of the stone. It is recorded as the percentage of surface area pitted out of the total surface area.

Surface abrasion of the stone needs to be recorded as it indicates the patterns of wear and abuse of the floor (**figure 2.13**). Because the floor is not regularly, thoroughly cleaned, it is particularly susceptible to abrasion from dirt and grit. In addition, the use of the space requires dragging large, heavy equipment across the floor, exacerbating the

amount of abrasion. Abrasion is recorded as the percentage of surface area visually interrupted by abrasion.

Discoloration of the stone damages the unity of grandiose space in the Great Hall (**figure 2.14**). The goal of documenting the discoloration is to find a pattern that will demonstrate its cause for, and lead to a treatment recommendation. For example, one theory is that much of the discoloration is due to the water that enters through the leaking roof and dome. Stones with calcareous binders, such as marbles, are difficult to clean because of their sensitivity to acidic solvents.

The condition of the bedding mortar throughout the floor is in a precarious state. In order for the tiles to be in a stable condition, the bedding mortar must be in a stable condition (**figure 2.15**). When a tile is not properly set in mortar with complete adhesion of the underside of the tile, the tile will be particularly vulnerable to mechanical damage due to a lack of structural support. The bedding mortar below each tile will be documented with two conditions. The tile may be visibly detached from the bedding mortar, and can be physically moved with the force of a footstep. The second condition of the bedding mortar is determined by whether the tile sounds detached when lightly tapped. If the tile sounds hollow, it is detached, if solid, the bedding mortar is intact. Both conditions are recorded as detached, not detached or partially detached. The sections of partial detachment are particularly important to note since they may be particularly vulnerable to more cracking.

The only inherent property of the stone that will be recorded is the presence of natural cracks and fissures. This will be useful in predicting where breaks, losses and pitting may occur, and may also explain losses already sustained.

After surveying each stone, the integrity and condition of the pointing mortar was surveyed. A graphic condition assessment was used to document the condition – the conditions and treatment recommendations for the mortar were fairly consistent throughout the sample section. Graphically surveying the mortar was the most straightforward approach; if the geometry of the floor had been orthogonal, it would have been conceivable to record certain joints with each tile. Six conditions were recognized in the mortar, created from combinations of original material and replacement material, stable or deteriorated condition, and finally treatment recommendations (replace or leave existing mortar) (**appendix C**). Because mortar is intended to be a sacrificial material, there is not an emphasis on retaining this fabric, rather the goal is to have the pointing mortar in a stable condition so that it can function properly and keep moisture out of the bedding mortar.

The methodology used to create a unique identifier for each stone needs clarification. The strict Beaux-Arts planning employed in the construction of Memorial Hall, enables one to predict, with great assurance, the original design of the floor. It is for this reason that each tile is treated as if the original were present, regardless of alteration. Each stone, as it would have originally appeared, was randomly assigned a

unique number. In one area, a single, large stone has replaced approximately ten original tiles (see figure). In this plan, the tiles are represented as they would have appeared originally because one goal is to calculate the cost and feasibility of intervention, and this will require that stones be treated as they should be replaced, not in their current, inappropriate condition. For example, the place of each original stone will have a survey form that follows:

> Replacement? Yes No Partial. Appropriate? Yes No.
> Describe: complete replacement with inappropriate marble type, size and geometry.
> Treatment recommendation: relay tile with X stone with proper geometry.

GIS Methodology

The first step was the completion of a measured drawing of each tile, to a ¼ inch precision. Only tile size was measured because the mortar joints were not addressed in the stone condition survey. Furthermore, the joints could not be reliably measured without proper surveying equipment. After measuring the tiles, they were drawn using AutoCAD 2000. Each stone type was given its own layer and all tiles were drawn as distinct, closed polygons (**figure 2.16**).

After determining the format and methodology for the condition survey, the AutoCAD drawing was inserted into *Esri's ArcView*. The drawing was saved as a *.dxf* file from AutoCAD to the working directory for the *ArcView* project. After opening *ArcView*, the floor was added as a theme and converted to a shape file. The table

associated with this theme showed that all of the tiles were polylines, rather than polygons. This was a temporary obstacle in the process, because in order to perform the necessary operations in *ArcView*, the tiles had to be recognized as polygons in the shape file. This left several options to create the necessary polygons within *ArcView*. The tiles could have simply been drawn in *ArcView* as new polygons, by simply tracing from the original shape file. This simple task would have been fairly time consuming, so several attempts were made to create polygons from the existing polylines. After consulting with Ben Haavick at the Fairmount Park Historic Preservation Trust, a script from the *Esri* website was used to convert polylines to polygons.[2] This script was loaded into the project file, and tested on the entire floor which resulted in a set of polygons, but approximately 30% of the tiles were not converted. After running the script on several test samples, it was discovered that smaller areas offered a higher yield of total polygons – using ¼ of the floor as a test area yielded almost 90% conversion into polygons. This was performed on each quadrant of the floor, creating a nearly complete polygon theme (**figure 2.17**).

After creating these four themes, they were merged into one theme using the *GeoProcessing Wizard*. This command allows two or more themes to be merged together into one, selecting one table to use as the basis for all of the other themes. This was successful in creating one theme with nearly all of the tiles represented as polygons

[2] www.esri.com, http://gis.esri.com/arcscripts/details.cfm?CFGRIDKEY=125825073

(**figure 2.18**). The theme was then edited and the missing polygons were added. A new number field was added to the table associated with the polygon theme such that a unique identification number could be given to each tile.

The graphic condition survey of the mortar joints was added to the *ArcView* project as a new polyline theme, and was added to the views as a new layer on the plan. Because this information was so straightforward and did not necessitate any sort of database for information management, graphic treatment was sufficient.

The stone condition survey was input into an Excel spreadsheet represented by all numeric values, added to the ArcView project as a new table, and then joined with the existing table for the polygon theme. This provided the database for analyzing the deterioration patterns and costs associated with conservation of the floor in the Great Hall as well as its regular maintenance. This information was then manipulated to demonstrate the deterioration patterns and decay mechanisms active in the floor, and to calculate the amount of area affected by these conditions, which ultimately lead to treatment recommendations. The polygon themes were converted to grid themes for each condition, creating a series of layers. These layers of grid themes were used to query the maps, resulting in the set of images seen in chapter 4.

CHAPTER 3 – DATA COLLECTION

The process of collecting the preliminary data for this project has required a wide breadth of research and a variety of methods for investigation. It has necessitated the examination of stone conservation, structural conservation, the conservation of flooring materials, the history of the site, and the use of GIS technology for cultural resource management.

A brief history of Memorial Hall has been summarized, using both primary and secondary research. Much information has been published on the conservation of stone and other porous building materials. However, the review of that literature is outside the scope of this thesis. Most of this literature deals with architectural applications of stone in an unprotected environment, whereas this floor is protected. Only the methods used in this project will be discussed. The same situation is true for structural conservation. The existing body of published research has neglected the conservation of historic floors – little has been published on conservation projects focusing on floors, and most of the extant literature deals with large, European cathedrals and archaeological sites. This literature will be reviewed in detail because the theory behind the treatment of ecclesiastical floors can be applied to Memorial Hall, but with considerations being made to account for differences in use and significance.

Brief History of Memorial Hall

With any conservation project, the history and significance of the site need to be understood. In order to understand how the site has developed and how the fabric, use and significance have changed, it is necessary to have a general history of the site to help guide the conservation plan.

Henry J. Schwarzmann (**figure 3.1**) designed Memorial Hall for the Centennial Exhibition of 1876, at a cost of $1,500,000 paid by the City of Philadelphia and the State of Pennsylvania, as a permanent structure to memorialize the Centennial of American Independence. The building was situated in a prominent position on the plateau, just northeast of the main exhibition building (**figure 3.2**). During the exhibition, it housed the primary art galleries (**figures 3.3 and 3.4**).

Schwarzmann designed the structure entirely out of iron, stone and glass. No wood was used in construction (**figure 3.5**), in the attempt to make the building "thoroughly fire-proof."[3] The building, designed in a modern renaissance style was built on a terrace six feet above Lansdowne Plateau. The front steps provided the primary access into the building and were flanked by large bronze sculptures of horses. The overall dimensions of the structure are 165 feet long by 210 feet wide and 59 feet high over a twelve-foot basement. Iron was used exclusively as structural members, in place

[3] From Schwarzmann's summary of the construction. United States Centennial Comission. *Grounds and buildings of the Centennial Exhibition, Philadelphia, 1876.* Ed. Dorsey Gardner (Washington, DC: Government Printing Office, 1880) 61-62.

of wood.[4] The plan was rectangular with a square tower in each of the four corners, built around a central, domed space. The primary entrance was located on the south elevation, which led through a monumental entrance into the atrium. The atrium follows through an arched colonnade to the central, domed space, or the Great Hall. At the north end of the Great Hall, a second, symmetrical arched colonnade leads into a hallway to other exhibition spaces. Two open-air arcades extended to the east and west of the atrium, and additional exhibition space extended to the east and west of the Great Hall.

In his report to the Director General of the Centennial Commission, H.J. Schwarzmann listed the dates when projects commenced and ended, and some problems and issues that arose during the construction processes. A competitive design was held for the design of both Memorial Hall and Agricultural Hall, but on April 11, 1874, when no decision had yet been made, Schwarzmann began working on plans. On June 2, 1874, he submitted plans for Memorial Hall, and they were approved by the Centennial Board of Finance, and specifications were prepared. On June 8, the Park Commission approved the same plans. On June 11, the square footage of Memorial Hall was reduced by 30%, in order to remain in the allocated budget. On June 22, R.J. Dobbins was awarded, as the lowest bidder, the contract for Memorial Hall, and the square footage was again increased by 30%. On July 1, new plans and working drawings were begun, and a large team of draftsmen was employed. On July 6, R.J. Dobbins began to grade the ground for

[4] James McCabe. *The Illustrated History of the Centennial Exhibition Held in Commemoration of the One*

Memorial Hall and the first materials construction materials were brought onto the grounds on July 23 on the first freight train. Masonry work began on July 23, and on August 8, the principal drawings were completed and approved. On the 4th of July, 1875, the figure on top of the dome was placed into position. The granite work on Memorial Hall was completed on August 28, 1875. On January 6, 1877, all drawings and papers were turned over to the archives in Memorial Hall.[5]

The general sentiment towards the design was mixed. One account states that the building was ill designed for art exhibition, leading to the design of the Art Annex. Furthermore, this same account describes the buildings as "satisfactory" and the design as "spiritless and uninteresting...pretentious and inelegant."[6] Other contemporary accounts of the structure describe it as "rich and tasteful."[7] Despite the positive and negative feedback surrounding the design and construction of Memorial Hall, there was a general excitement in Philadelphia. There were frequent newspaper articles giving updates on the work at the exhibition grounds. Tickets were even sold to the public before the grounds were opened so that they could have a first hand account of the activity

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Hundredth Anniversary of American Independence (Philadelphia: The National Publishing Company, 1975) 191-192.

[5] H.J. Schwarzmann, " Exhibition Grounds and Permanent Buildings" in United States Centennial Commission. *Report of the director-general : including the reports of the Bureaus of administration* (Washington, DC: Government Printing Office, 1880)

[6] Rebecca Trumbull. "Memorial Hall: A History, Prepared for The Fairmount Park Council for Historic Sites" (Fairmount Park Commission Archives, Philadelphia, 1986, duplicated), 6-7, quoting "Centennial Architecture," in *American Architecture and Building News* I. 178.

[7] *Ibid*, 6-7, quoting Thompson Wescott, *Centennial Portfolio 1876: A Souvenir of the International Exhibition.*

happening in the city. In fact, next to the Japanese House, Memorial Hall seemed to be the favorite destination (**figure 3.6**).[8]

After the Centennial Exhibition, Memorial Hall functioned as the primary exhibition space for the Pennsylvania Museum and School of Industrial Arts. In 1880, the School of Industrial Arts moved its headquarters to the 1700 block of Chestnut Street. This date marks the early point at which frustration surrounding the building began to develop. The City of Philadelphia and State of Pennsylvania were incapable of providing the required repairs for the building, and the building was unsuitable for the exhibition and storage of the Museum's growing collection. Several modifications were proposed to better adapt Memorial Hall to the needs of the museum, including the closure of the eastern and western arcades. However, despite these modifications, the current building that houses the Pennsylvania Museum of Art was constructed in 1926, leaving Memorial Hall to house small exhibits. In 1933, due to the Great Depression, Memorial Hall was closed indefinitely. By 1935, sections of the building were reopened, including the offices, library, and exhibits for ten weekends during the summer.

In 1949, the Commissioners of Fairmount Park set aside approximately one third of Memorial Hall for a recreation center which opened in 1950. From 1954-55, an auction was held in order to sell the Museum's surplus possessions, and in 1956 Memorial Hall was taken over by the Commissioners of Fairmount Park. In the years

[8] *Centennial Scrapbook*. Newspaper Clippings. Library Company of Philadelphia.

from 1959-1979 there were many changes to the fabric of Memorial Hall. Many necessary repairs were completed, and a new, staged renovation plan was instituted. Sky lights were installed, a new basketball court and men's locker room was placed in the West Main Picture Gallery, heating and electrical systems were updated, and in 1962 swimming pools were installed in the East Main Picture Gallery.[9] In 1964, the City auctioned off approximately 1,500 square feet of the stone tile flooring removed for the installation of the swimming pools.[10] In 1967, the western courtyard and arcade, and north rooms were taken over and turned into office space for the Fairmount Park Police and their administrative offices.

During the past two decades, several feasibility studies and conservation plans have been completed for Memorial Hall. The most thorough plan, completed in 1988 by Atkin, Voith and Associates, describes a plan for better adapting the building as a reception hall and summarizes the changes necessary. They suggested changes such as making the south entrance the primary entrance to the Great Hall, as it had been originally, and landscaping appropriately to accommodate this change. They also suggested creating reception rooms in the spaces immediately adjacent to the Great Hall, adding a catering kitchen, and maintaining the existing office space for Fairmount Park Commission, the Philadelphia Police and the recreation center (**figure 3.7**). The cost

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[9] Rebecca Trumbull. "Memorial Hall: A History, Prepared for The Fairmount Park Council for Historic Sites" (Fairmount Park Commission Archives, Philadelphia, 1986, duplicated), 1-5.
[10] "Memorial Hall Marble Floor To Be Sold." *Philadelphia Inquirer*, 19 March 1964.

estimate for better adapting Memorial Hall was $3,172,000.[11] An estimate for repair of Memorial Hall was completed in April, 2000, with the goal of making the entire building water tight and repairing the Great Hall and its ancillary spaces. The 2000 cost estimate was $10,633,193 – but included systems upgrades and changes, fire protection and ADA compatibility including the installation of an elevator. Even excluding the costs not included in the 1988 survey, the 2000 estimate is approximately $8,000,000, which is astronomically higher than the estimate of less than 15 years ago.[12] For example, the 2000 estimate for roofing work is approximately $2,600,000, whereas the 1988 cost estimate was $765,000. Although these studies are not directly comparable due to differences in the scope of work, the startling increase in just over 10 years for similar repairs makes a case for the restoration of the building sooner rather than late. If Memorial Hall is ever destined for a full scale conservation plan, then this drastic increase in price, and probable corresponding deterioration in condition, should make a case for conservation sooner rather than later.

Currently Memorial Hall houses the offices for the Fairmount Park Commission, a research center and a precinct of the Philadelphia Police, the Fairmount Recreation Center, and the Great Hall is rented out for special events.

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[11] Atkin, Voith and Associates. "Memorial Hall: A Feasibility Study for the Restoration and Adaptation of the Major Public Spaces." (Fairmount Park Commission Archives, Philadelphia, 1988, duplicated), 1-10.
[12] Correspondence from John Donnelly from LF Driscoll Co. to John Bingswanger. From Fairmount Park Archives in the "Memorial Hall" folder, dated April 21, 2000.

Characterization of Materials

Although the Centennial Commission kept records in great detail, there are few accounts for the construction processes and the materials used in the construction of the floor. There was one contemporary reference, by James D. McCabe that lists the suppliers for the materials used. The iron work was furnished by the Edgemoor Iron Company, the Pencoyd Rolling Mills, and the Kittredge Cornice Company, and the stone-work was furnished by Sargent & Co., the Westham Granite Company, the Conshohocken Stone Company, S.F. Prince and Co., and the Excelsior Brick Co. The glass was furnished by Shoemaker and Co., Ward and Co., and J.M. Albertson.[13] In addition, there is reference in the 1885 fire insurance survey (**appendix D**) to the use of flag, granite and Pennsylvania blue marble for all of the floors.

Mortar samples were taken from the floor in order to better understand the original construction techniques (**appendix E**). Four samples were taken from throughout the Great Hall. Three samples were taken because they were thought to be original, from beneath stones that were visibly detached from the bedding mortar, but did not have past repairs. The fourth sample was taken from an area where there had been a previous repair. The area of repair had a harder binder and an aggregate that appeared to be industry standard silica sand. The aggregate to binder ratio was typical, with nearly 60% aggregate, and the reaction with hydrochloric acid was not as violent as the other

samples, indicating the likelihood of a Portland cement and lime mix. The other three samples had a lower percentage of aggregate, 40% - 54%. Because the particles are angular and there is a high content of mica, it is likely that this sand was mined on site to use in the wet bed. This sand was not ideal for a wet bed, so the builders may have used extra binder in order to over compensate for an unsuitable aggregate. The high percentage of binder, 40% - 53%, had a more violent reaction with hydrochloric acid, making it probable that most of the binder is lime. In addition, the historic samples may have a pozzolan additive for hydraulic purposes.

The stones used for the tiles vary from marbles to breccias. The pink stone has been identifies as a breccia, because it is hard and non-reactive with hydrochloric acid. When scratched with a steel blade, the pink stone was much more resistant to abrasion than the marbles. The gray, black and white stones, all reactive with concentrate hydrochloric acid, are probably marbles. The fire insurance survey (**appendix D**) states that the white stone used on the floors is Pennsylvania Blue marble, but this may be incorrect since Pennsylvania Blue tends have more veins and a darker color.

Literature Survey

Floor Conservation

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[13] James McCabe, *The Illustrated History of the Centennial Exhibition Held in Commemoration of the One Hundredth Anniversary of American Independence.* (Philadelphia: The National Publishing Company, 1975) 191-192.

One monograph has been published dealing exclusively with historic floors.[14] It is a compilation of essays whose topics primarily focus on cathedrals, churches and chapels, both in an archaeological context and as living, functioning spaces. The treatment of these spaces, although not necessarily similar in use, details or materials, are a good starting point for a methodology of treating the floor in the Great Hall of Memorial Hall.

The biggest problem concerning the conservation of flooring materials has been the historical indifference to floors as important cultural heritage. There is a general misconception that floors can take care of themselves as a self-sustaining system. Even in England, after the implementation of a comprehensive survey of 44 church floors, there was still a bias against floor conservation by church officials, architects and conservators who would be willing to tackle problems concerning other construction systems in the buildings. However, in 1991, a program in England, the Care of Cathedrals Measure, required that by 1996 inventories for cathedrals be completed, including the floors.[15]

Excluding structural failure, stone floor deterioration results primarily from the movement of visitors and equipment across the floor (depending on the use of the site), alterations to the original fabric for the installation of new systems or equipment, previous repairs and attempts at surface protection, and the laying of inappropriate

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[14] Jane Fawcett, ed. *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998).
[15] Jane Fawcett. "Floors" in *Treasures on Earth: A good housekeeping guide to churches and their contents,* Ed. Peter Burman (London: Donhead Publishing Ltd, 1994), 179-190.

carpets, other coverings and stanchions. These conditions can result in the erosion of the surface or the loosening of the tile from the bedding mortar. The surface loss, especially with a stone tile, is largely cosmetic. However, the loosening of the tile from the bedding mortar presents a more serious problem. When the tile becomes loose, the bed begins to be ground and weakened by the movement, eventually weakening the structural support of the tile. This often results in the cracking or shattering of the tile.[16]

However, there is a very real need for historic floors to function, making it necessary to strike a balance between preservation and day to day operations of the building. For example, dragging equipment and furniture across delicate surfaces will cause damage, especially to a floor that is not properly maintained. Many cathedrals are used as public spaces for functions like concerts and other events. However, they are often historic structures with delicate fabric that were designed as places of worship, and this use is contrary to the original design. It is possible to better manage visitors utilizing the site. Properly placed mats can reduce the amount of dirt brought in by foot traffic by almost 90%. In highly sensitive and important areas, sections can be cordoned off with wooded floors, but this decontextualizes the fabric. Coating with protective barriers, such as microcrystalline waxes, have caused discoloring in the Chapter House of Westminster Abbey, and they can become a maintenance problem. Areas can be roped

[16] Tim Yates and Sandra Davison, "Tile Pavement and Floorwear" in *A Future for the Past*, Ed. Jeane-Marie Teutonico (London: James and James, 1994), 99-107.

off, but the change and concentration of foot traffic in other areas may cause increased wear in other areas.[17]

Until recently, floors have not been regularly recognized as important, historical features. This recognition is an important first step in floor conservation. Another step in the conservation of this abused building element is as simple as keeping it clean. Significant abrasion is caused by everyday grit on the floor, getting ground in with the traffic of visitors and equipment. Vacuuming and regular cleaning with water are ideal, and the introduction of heavy cleaning equipment and chemical cleaners should be carefully reviewed. However, floors were made to walk on, and like all other building elements, are subject to deterioration. In addition to treatment, it should be the goal of any conservation plan to fully document the current condition of the floor.[18]

An important issue in the conservation of church flooring is the moving of tiles and other elements such as ledger stones and brasses. It is inappropriate, under most conditions, to conserve stones by moving them from their original position, unless they have been destroyed by a previous treatment and present a hazard.[19] However, many floors have been shuffled about through past recycling and restoration campaigns, making interpretation difficult. Ledger stones in church and cathedral floors present a

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[17] Jane Fawcett. "Use and abuse: management and good practice in cathedrals and greater churches." In *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998) 113 –123.
[18] *Ibid,* 123-129.
[19] Peter Bird, "Winchester Cathedral: conserving the retrochoir pavement" in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998). 115-116.

confusing problem, because they were often cut down and shifted with new burials in an already crowded floor.

Documentation, as with most aspects of architectural conservation, is important to consider in flooring projects. One method of documentation is to produce a map of the area to be recorded through traditional surveying techniques to create a base plan as accurately as possible. However, it is impossible to create an "accurate" plan of a historic floor due to the inherent and accumulated flaws in the slabs, tiles and mortar joints. In addition, most equipment has intrinsic flaws, also reducing the level of accuracy. Therefore, all measured elements should be interpreted with a degree of tolerance. Different methods can be employed for surveying, dependent upon the space to be surveyed, and the degree of accuracy necessary to be obtained. Hand, instrument and photographic surveying methods each have their own merits and drawbacks, and should be selected dependent on the needs of the project to be completed.[20] To supplement the survey, it is often useful to have a photographic record. Generally, photographs can be useful in two broad classifications. The first is typically used as a reference to aid in remembering aspects of the floor after the field-work is completed. The second is more detailed record photography, used in reports and specification

[20] Ross W. A. Dallas, "The surveyor's approach to recording floors" in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998). 85-93.

guidelines. In the Memorial Hall survey, simple surveying techniques and photography were used to document the current condition.[21]

The overarching theme throughout the literature is that a conservation plan will not take the place of regular and sustained maintenance.[22] If regular maintenance and monitoring are not taking place, conservation work becomes exponentially more expensive.

Floor Conservation Case Studies

Several case studies covering the conservation of historic floors have been published, discussing the conservation options available. The history of York Minster is a good example of a complex history that has directed the conservation plan for the floor. In 1731, the Dean and Chapter gave an order to tear up the majority of the ancient, uneven floor of ledger stones and brasses, to be replaced with a new floor of black and white design. The only flooring that remained intact after this repaving campaign was the area east of the high altar, where internments continued until 1836, and now contains numerous ledger stones. In 1989, it became apparent that action needed to be taken due to the damage being caused by the 2 million annual visitors. Objects and furniture were moved to redirect traffic around the significant ledger stones and slabs. The floor was

[21] Robert Skingle, "Photographic recording of floor surfaces and components" in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998). 94-100.
[22] Peter Bird, "Winchester Cathedral: conserving the retrochoir pavement" in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998), 119.

recorded in a stone by stone survey using forms, photographs and rubbings. After the condition was determined, each stone was given a grade, *Grade I* or *Grade II. Grade I* stones were of great historic or artistic merit, should not be moved or replaced with replicas, and should be conserved *in situ*. The condition of each stone was recorded, and treatment recommendations were made. The list of potential recommendations ranged from removing foot traffic by creating barriers around the stone, repositioning the stone to an area of less foot traffic, moving stones to a museum, re-cutting inscriptions into an existing stone, replacing stone with a replica, renewing stones but with a new design, covering the stone with a protective finish, and leaving the stone as is thereby accepting that the inscription will disappear. Each possibility for treatment had its cautions and benefits, and the author did not necessarily support all of the actions being taken.[23]

The floor in Winchester Cathedral is an impressive collection of medieval, encaustic tiles, and the increase in visitation has caused alarm for the their condition. In 1990, the floor was recorded using rectified photography and a condition survey was completed. It was noticed that a hard, red mastic had been used on a large area of the floor. Initially, the conservation team thought that the red mastic would damage the original tiles through preferential drying and salt crystallization. However, mechanically removing the red material proved to cause more damage than leaving it in place, and was not responsive to chemical and thermal removal. The final conclusion after testing

[23] Charles Brown, "York Minster ledger stones: conservation options" in *Historic Floors: Their History*

removal techniques was to leave the red mastic in place unless the tiles needed repair. All loose cemetitious and red mastic joints were pecked out, cemetitious repairs were removed, then grouted and repaired *in situ* using a colored hydraulic lime. Cleaning tests were carried out on the medieval tiles, using cotton wool with acetone, deionized water, and deionized water with a wetting agent. The deionized water worked as well as the wetting agent, so unamended deionized water was used. The tiles were consolidated using two coats of 10% B72. The team decided that all tiles should remain *in situ*, with the exception of those that were entirely fragmented or inappropriate modern replacements. All inappropriate replacements and fragmented tiles were replaced with modern replica tiles.

This project also included the removal of an effigy in the north aisle because it created a funnel for foot traffic over a fragile section of pavement. By changing the position of the effigy, the concentration of the wear in that area was reduced. Generally the use of barriers was rejected because they tend to exaggerate wear in certain areas, rather than creating a more uniform wear across the entire floor. In addition, Winchester Cathedral is a living building, so it is unreasonable to exclude people from certain areas. Currently a test is being carried out on an entirely open section of the floor to test the damage resulting from free access of traffic versus the funneling of traffic. Preliminarily, it appears that free access mitigates the overall damage to the floor. This project was

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and Conservation. (Oxford: Butterworth Heinemann, 1998). 79-84.

successful in reintegrating the color and quality of the tiles and restoring the visual unity of the original tiles.[24]

The Palace at Westminster has encaustic, colored tiles in the primary circulation areas. Because of the intensive use, the more heavily utilized floors are approaching the end of their functional life, resulting in the loss of patterns and a slight undulation in the level of the floor. The concept for the tile floors is an integral element of the overall architectural design, and the loss of the color and patterns has had a severe visual impact. There are three primary consequences of deterioration – historical, aesthetic and safety. Because this structure is a living, highly utilized building, heavy use of the floors is inevitable, and their deterioration is expected. Regular cleaning using a slightly damp mop with clean water has helped to mitigate the loss of fabric, and no polishes were used. Dragging equipment across the floor was also of concern, but was lessened with the use of soft-wheeled trolleys. For the condition survey of the floors, each tile is examined individually, and categorized on a tripartite basis and differentiated by color. The goal of this plan was to retain original fabric until it either became a hazard or it seriously detracted from the original design. As a result, tiles were replaced with replicas only when they were "aesthetically unacceptable" or unsafe.[25]

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[24] Peter Bird, "Winchester Cathedral: conserving the retrochoir pavement" in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998). 113-119.

GIS and Cultural Resource Management

GIS software (geographic information systems) is a relatively recent tool in the field of cultural resource management, and becoming increasingly common in State and Tribal Historic Preservation Offices (SHPO and THPO). Formerly, GIS has been used in larger scale, geographic studies, as the name would imply. Since cultural resource professionals have begun to realize the capabilities of GIS, the National Park Service has recently developed a software program for SHPOs, called *MAPIT*, a customized version of *ESRI's ArcView 7.* This program allows the user to locate, inventory and study a state's cultural resources. Virginia MAPIT was the pilot program, and this created a project of increasingly more detailed levels of inquiry for the cultural resources on record. The largest scale was at the statewide level, where issues such as distribution patterns can be understood. The county level was a powerful tool in understanding local patterns. The property level describes an individual site, with links to maps, images and pertinent documents. One benefit to using a GIS in the context of a SHPO is the ability to work on several different levels and scales simultaneously and to understand the interactions between different scales of material culture. [26]

In Shenandoah National Park, GIS has been used to integrate information from both natural and cultural resource standpoints, fire management, visitor protection,

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[25] A.T. Jardine "Encaustic pavements. Conservation, protection and replacement issues: The Palace of Westminster," in in *Historic Floors: Their History and Conservation.* (Oxford: Butterworth Heinemann, 1998). 187 –197.

backcountry management, pest management and facilities management, in order to protect its resources, specifically archaeological, from deterioration due to both natural and unnatural causes. An important aspect of this is the ability to locate the resources to be protected. Using GIS to map information such as trail networks, campsite distribution and backcountry management boundaries, is a straightforward method to evaluate which sites are at risk from aggressive use. In this case, a Geographic Positioning System (GPS) was used to create the map of the park and its sites, after certain areas were identified with USGS quadrangle maps (1929), court records and aerial photography from the National Archives (1937). This information was mapped using several layers for many features in different time periods. Information such as digital images and documents will be stored in the database that will be linked to the *ArcView* project. Future work for this project will include the integration of elevation with the GPS coordinates, which will create a more comprehensive picture of the landscape, including agricultural terraces, which were a widespread practice in the bottomlands as agriculture intensified. This use of GIS creates a comprehensive program to locate and document areas of cultural importance, and to determine the factors that may have an impact on their survival.[27]

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[26] Deidre McCarthy. "Applying GIS Technologies to CRM." *Cultural Resource Management* 21.5 (1998): 34-35.
[27] Dan Hurlbert, "GIS as a Preservation Tool at Shenandoah." *Cultural Resource Management* 21.1 (1998): 26-28.

The potential of GIS has also been recognized as a tool for the analysis of condition on the scale of a building, monument or object. This approach to conservation with a GIS works well, because any surface, whether a wall, painting, or view shed, can all be conceived of as geographic surfaces, although somewhat humanly contrived. ArcView was used as an analytical tool on the Jefferson and Lincoln Memorials for their stone by stone condition survey that was developed in order to document the marble and limestone deterioration. In this project, both the CAD drawings of the structure, which represented each stone as distinct polygons, and the stone condition inventory already existed. Both sets of data needed to be integrated into a system that would present the information in a intelligible manner. GIS was the tool chosen for this task because it made both sets of information more easily accessible, and much more powerful in its analytical abilities. The CAD drawings, as they were initially completed, were much too large to be manipulated in *ArcView*, so all of the detail and extraneous layers were eliminated. All database information was saved as a dBASE in excel. Then each stone was given a unique identification number that was based on the original stone setting numbers for the memorial. This information was linked to the dBASE record of the condition survey using *ArcView's* join command. In this project, the use of *ArcView* has several benefits – it can be operated by someone with basic Windows skills to perform simple queries, but can still be used for complex structural analyses. For example, stones with certain conditions can be highlighted to create a visual image where that condition is

present, which can be related to structural problems in order to better understand what conditions are causing structural instability. This use of GIS can develop a protocol for a systematic maintenance program.[28]

[28] Kyle Joly, Tony Donald and Douglas Comer. "Cultural Resource Applications for a GIS Stone Conservation at the Jefferson and Lincoln Memorials." *CRM* 21.2 (1998): 17-18.

CHAPTER 4 – ANALYSIS AND RECOMMENDATIONS

The goal of this project is to give the user a powerful and user-friendly tool for accessing and analyzing the information gathered in this project. After the completion of the survey and database, a GIS will be used as an analytical tool to aid in recommending a treatment and maintenance plan. It is important to have the capacity to efficiently and effectively develop a conservation and maintenance plan as funding becomes available and based upon the work with the highest priority. By clicking on any given stone, the condition, conservation recommendations and past treatment records can be accessed.

Esri's ArcView allows for creating themes based on conditions, making an effective tool for understanding the decay mechanisms active and present. For example, it is likely that there is a pattern of failing bedding mortar where water pools on the floor from the leaking roof. This hypothesis can be tested by joining the two conditions in order to determine the degree to which they intersect with one another.

One goal for this project is to understand the decay mechanisms affecting the floor and to design a maintenance plan to address these conditions. *ArcView* will be used as the tool to first determine areas of deterioration and then to calculate areas with the highest priority for treatment and the total costs for implementation. It is intended that this project will not only provide a tool for the design of the maintenance plan, but will also establish a prototypical methodology that can be used for other conservation projects.

The treatment plan for the floor of Memorial Hall will be recommended in a hierarchical system. If funding were in place for a full-scale restoration of the building, creating a conservation plan would be a relatively straightforward process. However, because there is no plan for a restoration project, the work must be carried out as funding becomes available and as necessity dictates. Therefore the final recommendations will have a section discussing the ideal process for restoration, and also a section discussing recommendations for phased maintenance to be implemented with all ensuing repairs and maintenance on the floor. In addition, there will be a section discussing general, appropriate recommendations for protecting the floor in its everyday use.

Results of Condition Survey

One section of the floor was used as a sample for the condition survey. This eighth of the floor was chosen because it represents a complete sampling of all stone dimensions and types, and it was the most obviously worn and highly trafficked section. It represents a sampling of all of the conditions pervasive throughout the floor.

Before the condition of the floor and proposals for treatment can be discussed, the overall condition of the building must be addressed. The roof leaks around the perimeter of the dome, and has since construction (**figures 4.1 and 4.2**). As long as this extreme situation of water infiltration continues, restoration of the floor has a low priority, because the water will continue to cause damage. Standing water works its way into the

mortar joints on the floor, and is creating weaknesses in the bedding mortar. If the leaks are not repaired, there is little merit in discussing potential treatment recommendations.

The initial design of the wet bed for the floor, with the high lime to aggregate ratio, has created a weak foundation for the stone tiles. In addition, water infiltration into the mortar with a high lime content is a primary cause of the deterioration of the bedding mortar, causing its inability to support the tiles, and allowing the ensuing cracking. In looking at the pattern of standing water distribution (from rain storm on January 19, 2001), there is a trend that the most serious cracking and visible detachment are centered around these areas (**figure 4.4**).

The condition of the bedding mortar is one of the largest factors creating instability in the floor. If the bedding mortar is unstable, the stone tiles set on it will not have the structural support necessary to perform allowing for deformation, cracking and other conditions to result. The condition of the bedding mortar manifests itself if the tile either sounds or is visibly detached from the mortar. The tiles were recorded as either sounding detached when lightly tapped, or by being visibly loose from the mortar bed. Each condition was recorded as detached, partially detached or stable in the database. Detachment, both visual and sound, is present in most of the test area (**figures 4.5 and 4.6**). Many of the tiles that were partially, visibly detached from the bed were not necessarily loose from the bedding mortar, but flexed in the mortar bed with little force. The areas of the highest priority are those tiles that are either partially or completely

visibly detached because both the loose tiles present a hazard to the users of the space, and the movement and differential support present an increased risk for fracture, abrasion and chipping for both the loose and the adjacent tiles.

Unsympathetic repairs have seriously compromised the integrity of the floor (**figures 4.7, 4.8 and 4.9**). The most typical repairs are reset tiles, fills in small cracks and patches with inappropriate materials, or a combination. It is apparent when a tile has been reset inappropriately, because many were simply removed from the mortar bed, and the new bedding material was placed on top of the existing mortar, skewing the tile out of the plane of the original floor. This can potentially make the stone more vulnerable to abrasion and chipped corners, and can create a hazard. It can also cause damage to the repaired tile and those adjacent to it due to the incompatibility of the materials that have a different hardness, water transfer capabilities, and adhesion. The new cementitous mortar is much harder than the original stone and mortar, thereby destroying the masonry floor system, where the mortar should act as the sacrificial material. With a Portland cement based mortar, the stone becomes the weaker material. Inappropriate materials, often asphalt or Portland cement, were used to re-point cracks and small patches. This creates similar problems in that the mortar is more durable than the stone – it is harder and less permeable to moisture, and is extremely difficult to remove from the stone. In addition, unsympathetic repairs also damage the visual unity of the floor – the original design was a strict Beaux-Arts plan, so alterations to the overall pattern are conspicuous.

The integrity of the fabric was investigated in order to determine what merited conservation or replacement, because the inappropriate replacement of tiles has been a source of deterioration. Replacement was recorded as total, partial or original (**figure 4.10**), then inappropriate or appropriate (**figure 4.11**), and finally all inappropriate replacements were described as either cementitious material, inappropriate stone, inappropriate dimensions, or a combination of any of these (**figure 4.12**). Cementitious materials are the most detrimental replacement materials, because they have a large impact on the material aspects of the floor, and create a disturbance in the visual pattern. This juxtaposition of materials and techniques may cause damage to the existing adjacent materials. In addition, removal of these materials has to be carefully considered because it may cause more damage to the surrounding tiles. However, leaving inappropriate materials in place may cause damage to the surrounding stones and will disrupt the composition of the floor. Inappropriate stone types and dimensions, which have been typically set in a Portland bed, detract visually from the overall floor, but the stones themselves do not necessarily damage the material of the floor.

Cracking has become a problem for Memorial Hall's floor (**figure 4.13**). Cracking is prevalent throughout, but upon visual inspection, it appeared to be concentrated in the area of access directly off of the primary corridor. Looking at the GIS image of cracking (which is represented visually by a gradient of severity, using natural breaks in the number range instead of equal intervals in the number range), it

appears that the most severe cracking is generally in close proximity to the entrance . The dimensions of each tile were another perceived factor causing cracking, from a visual inspection. In the general inspection, it appeared that the larger tiles had a tendency to crack and shatter more easily than the smaller. After completing a series of calculations in GIS, it is difficult to determine if there is a trend for larger tiles to crack more easily – there is a minor trend showing that the larger tiles had more severe cracking (**figure 4.14**). In reality, it is probably a combination of factors, including the original dimension and the amount of traffic, causing the cracking. Without having a larger sample area of the floor, it is difficult to accurately determine the factors causing cracking.

The cracks and the resulting fragments have been candidates for inappropriate repairs, and most of the repairs on the floor involve cracked tiles (**figure 4.15**). Furthermore, the presence of new, un-repaired cracking allows an unobstructed path for water and other contaminants to enter the bedding mortar.

Due to the deterioration of the mortar bed and the method for repairing loose tiles, most of the tiles are skewed out of the original plane of the floor. The plane of each tile was determined by the number of corners above, below or even with the plane of the floor. A visual investigation predicted what the GIS data supported – nearly all of the tiles are no longer in plane (**figures 4.16, 4.17 and 4.18**). This creates an uneven surface that is not safe and has arisen from improper maintenance and repairs.

The abrasion pattern is largely dependent on the stone's resistance to abrasion, the use patterns of the floor and the plane of the tile relative to those surrounding it (**figures 4.19 and 4.20**). For example, the gray, white and black marbles are much softer than the pink breccias, and tend to exhibit a higher percentage of abrasion. The area closest to the entrance off of the hallway exhibits a higher percentage of abrasion. Stones that have a lower plane relative to the tiles around it generally exhibit a lower percentage of abrasion. Conversely, tiles that are higher than those around it tend to exhibit a higher percentage of abrasion.

Discoloration of the stone has also become a problem. Some orange staining, probably ferrous corrosion byproducts, has developed, but manifests itself only on the white marble (**figure 4.21**). In addition, there is a faint yellow staining or clouding on a large number of the white tiles. This condition consists of a slightly yellow haze on the tile, and the surface of the marble appears to be more crystalline, and is more pronounced in areas without the marble's natural veining (**figure 4.22**). This may be the result of a surface finish such as a wax or coating, or simply from a slight deterioration of the surface that has created micro-cracks between crystalline particles and binder, allowing a small space where particles can be trapped.

Conservation Recommendations

The results of the condition survey have demonstrated that the current treatment methods, which have resulted in large sections exhibiting inappropriate repairs and replacements, are damaging the original fabric and the visual unity not only the floor, but also of the entire space of the great hall. Although there is no funding in place for a full-scale restoration of the floor, an ideal treatment plan will be laid out to demonstrate the options available for conservation. The ideal treatment plan for the floor can be guided by using a GIS as a tool for analyzing the necessary treatments, and recording all treatments for each tile. After the building is made water tight, the best option is to reset the entire floor in a new wet bed. The structural instability of the wet bed is so wide spread that resetting some stones or consolidating the bed in certain areas is counter productive. If money is to be reinvested into the floor, then it should be treated in a manner that will increase its longevity.

In order to reset the floor, the existing mortar must be removed. The pointing should be carefully chiseled out from between the stones. The original, soft lime based mortar is easily removed with non-abrasive, mechanical methods. The harder cement based mortars should be chiseled out, but if it is damaging the stone a conservator can remove it with Dremel Tool or a grinder. After each tile's joints have been removed, the stone must be detached from the bed. The tile can then be removed by undercutting the

mortar bed or by using lateral force to shear the tile from the bed. After the bond with the mortar substrate is broken, it can be safely removed.

After the removal of the mortar, all tiles must be properly cleaned. Cleaning soft, calcareous stones requires sensitive techniques, starting with the gentlest approach, which is water or water and a non-ionic detergent, then moving to more aggressive techniques such as alkaline cleaners. Poultices with a solvent may be successful in removing stains from the marbles. If all cleaning methods are exhausted, replacement with an appropriate stone tile may be appropriate.

The clean tiles should then be reset in a new hydraulic like wet mortar bed. It is during this phase that all dutchman repairs[29] should be made in areas where the tile has become too deteriorated, either through past repairs, shattering, pitting or abrasion. The mix for this mortar should be a 1:3 mix of hydrated hydraulic lime to aggregate. Because the aggregate originally used in the wet bed was not graded properly, the recommended aggregate is a fine, sharp sand, white or off-white in color.

The pointing mortar and the mortar used to fill cracks and areas of partial loss (where losses are no more than 1 inch wide) in tiles should be a 1:3 ratio of hydrated, hydraulic lime to aggregate mix. The aggregate should not replicate the original; instead, a finely grained aggregate should be used. In areas where the mortar will be used to patch small losses and cracks, a tinted lime should be used (factory mixed lime should be

[29] A technique used when a section of deterioration or loss is cut out and a new stone is used to fill the void.

used in order to maintain consistency). Tinted mortar will help to reduce the visual impact of the repair.

Maintenance Recommendations

It would take minimal cost and effort to simply change the method for repairing the floor. The use of Portland cement should be prohibited, and hydrated, hydraulic lime should be used as the binder. This simple change in approach would, over time, greatly improve the existing condition of the floor.

Because a full-scale restoration is not feasible at this time, a maintenance plan and guidelines need to be implemented to create short-term solutions for existing problems until a full-scale conservation treatment can be implemented. GIS can be used an analytical tool to create and prioritize a maintenance schedule from the stone by stone condition survey, and to monitor the treatment progression.

Abrasion is an active force destroying the surface of the stones. Although this damage is largely cosmetic, there are simple methods for reducing the amount of abrasion by reducing the amount of dirt and grit on the floor. This can be achieved through regular cleaning with clean water, and through strategically placing matting at all entrances. Placing at least 2 yards of carpet, at every entrance can reduce the amount of dirt on the main floor by up to 90%. The carpet needs to be chosen carefully so that it will not detrimentally trap dirt and grit against the floor. For example, it is not

recommended to use carpets with a rubber or plastic underside. However, the use of mats has to be carefully monitored if they are placed on a sensitive surface – they have the potential to trap dirt below and actually increase the amount of abrasion. In addition, the mats needs to be thoroughly and regularly cleaned so that they continue to remove abrasive particles. In this case, mats should be placed and maintained at the entrance to the Park Commission Offices at the western end of the building, the north entrance, and the southern entrance.

The unstable bedding mortar requires that the floor be treated more carefully than a stable stone floor. Under no circumstances should any equipment be dragged across the floor, because it may cause unnecessary abrasion, cracking and chipping. Because most of the tiles are not in plane with the surface of the floor, the edges of the tiles are vulnerable to chipping and dragging heavy objects across it will only increase this damage. Large pieces of furniture or mechanical equipment should not be dropped on the floor as the force from a dropped object is likely to break a tile that is not properly supported. Most of the floor is susceptible to damage because so much is detached. Damage can be avoided by implementing a policy to educate contractors and other individuals to treat the floor more carefully and use wheeled carts to move large or heavy equipment.

Maintenance and repairs should be sensitive to the existing fabric, and should take place after approval by the Fairmount Park Commission Historic Preservation Office.

All repairs should be completed by trained architectural conservators and carefully recorded in the GIS database, along with paper documentation of the repairs stored in the Fairmount Park Commission Archives.

The areas of highest priority for treatment are the tiles that are visibly loose from the bed. These tiles are both vulnerable to cracking and may provide a tripping hazard to the users of the space. In order to properly reset a tile, it must first be carefully removed from the floor. If the tile is completely and visibly loose, it is generally easy to lift it from the bed. If the tile is still partially set in the mortar, begin by first removing the pointing mortar. If the mortar is softer than the tile, use a small chisel and hammer, but if the mortar is harder, use a Dremel Tool to carefully cut away the mortar. After the pointing mortar has been removed, the rest of the joint should be carefully chiseled away by hand. The tile should be washed in water and any mortar should be mechanically removed without damage. Excavate at least 1-2 inches or until the bedding mortar becomes sound, and then cover the void with new mortar, using a 1:3 ratio of hydrated, hydraulic lime to aggregate (sharp, fine and white/off-white). Set the tile in the new bed, and properly level the tile. Then point the joints, shaping concavely, then finally carefully clean any excess mortar from the surface of the tile with clean water.

Cracks, small losses (less than 1-2 inches wide) and joints should be repaired as they begin to fail in order to seal the floor from water infiltration. If re-pointing a past repair of a fractured tile or an existing joint (assuming that the tile does not immediately

need to be reset), the old mortar should first be removed from the crack with a small chisel and hammer without causing further damage to the stone. The joint should be cleared of dust and debris by vacuuming, and then pre-wet. The cleaned joint should then be re-pointed using a soft lime mortar (1:3 ration of hydrated hydraulic lime to aggregate), scoring the mortar joint concavely. The stone around the mortar joint should be thoroughly cleaned of all mortar. The same method for re-pointing should be followed for recent fractures and partial losses that have not had previous repairs, beginning with cleaning the area to be repaired.

Although not a lower priority, it may be necessary to repair tiles that sound detached from the mortar bed because they are likely to crack with little force. These tiles should be removed and reset according to the specifications for resetting visibly detached tiles.

No repairs should be made to inappropriate replacement tiles. These tiles should be removed and replaced with an appropriate stone that will not visually detract from the overall composition of the floor. The breccia can be replaced with stones such as *Breccia Violetta* (Italy), or *Rouge Griotte de Santour* (Belgium),[30] the gray marble with *Bardiglio Imperiale*[31], the white marble with *Bianco Carrara C/D*,[32] and the black marble can be

[30] Christine Parsons. *An Inspirational Catalogue of Styles and Materials*. (London: Apple Press, 1990), 78, 87.
[31] http://www.francocaruso.com/inglese/Prodotti/MarmiSemilavorati/MarmiSemilavorati.htm
[32] http://www.brunolucchetti.it/materiale.htm

replaced with *Noir Belge* (Belgium).[33] The tile should be set following the procedure for resetting visibly detached tiles.

Any repairs or alterations made to individual tiles should be updated in the GIS database under the *polygonflr2* under any of the fields marked repairs. This is an efficient way to monitor the changes in condition and to track alterations to the floor.

Applicability and Efficacy of methodology and analysis for other projects

GIS can be a powerful tool for manipulating the information obtained through a condition survey. A stone by stone survey requires a database by its nature, and *ArcView* can potentially work well in this application because it can combine databases (in many formats) and the digital images in one program. The analytical capabilities of ArcView are unending, and it has the ability to combine existing information in patterns that would not necessarily be detected by human perception. The other benefit of using a GIS for conservation documentation purposes is that the information is recorded geographically, meaning that condition as relating to spatial relations can be analyzed. This is one of the benefits of using *ArcView* over *AutoCAD* or another drafting tool. AutoCAD has the capability to visually record geographic information, but cannot draw relationships spatially from the information.

[33] Parsons, 78.

Although *ArcView's* GIS can be a powerful analytical tool, it does have problems in this application. The learning curve for the program is high because it functions differently from most software that the general population is accustomed to. Most software programs create files that contain the information to be manipulated. An *ArcView* project, on the other hand, does not contain any information *per se*. It is used as a tool for looking at information in different places. If not properly trained, this concept is not intuitive, and many users run into problems managing projects.

After using this section of tiles for a test patch to understand the efficacy of GIS as a tool for conservation management, it is recommended that *ArcView* is a good tool for analyzing the results of a stone by stone condition survey. The use in the case of Memorial Hall worked well because there is already a GIS project in place for mapping structures in Fairmount Park, so an institutional knowledge of the software and its applications already exists.

CHAPTER 5 – CONCLUSIONS

This study has realized that floors are an understudied feature in the architectural conservation literature. They are an integral feature to structures, and should be given more consideration in the development of conservation plans. They are difficult to treat because they are, by nature of their use, destined to deteriorate. However, the deterioration process can be slowed through the implementation of various techniques such as regular, mild cleaning and simple steps to reduce the amount of dirt on the floor. However, because floors are not generally recognized as significant features, they do not have the same consideration as other building elements. Simply the recognition that floors are valuable would likely make a difference in the preservation of historic flooring materials.

Similarly, in this case study, the importance of Memorial Hall's floor has been demonstrated, and should be recognized by the Fairmount Park Commission as a valuable cultural resource. In addition, they should commence upon the recommended repair program immediately, and recording all changes in the aforementioned database. An overall conservation program, including the flooring materials, is recommended for the entire structure, due to its importance, both nationally and locally. Finally, the use of the space should be more carefully monitored to reduce the inappropriate use and unnecessary damage caused by large equipment and stages.

GIS has recently begun to be used in cultural resource management as a tool for analysis and management. The general consensus from the literature is that GIS is an effective method for data management in cultural resources. It allows for the convergence of several data sources, including images, databases, historical information and conditions. However, the software is expensive, and the learning curve to effectively utilize the program is quite steep. However, despite the obstacles, several projects have successfully used GIS. It is effective both for looking at a regional scale to investigate cultural patterns, and also for looking at small-scale patterns on a humanly contrived geographic surface, such as the surface of a building. The analytical capabilities of GIS can present the information of the survey both graphically, tables of data sets and in charts and graphs. The analytical capabilities are unlimited, and it is possible to understand condition spatially.

GIS has been predominately successful for the investigation of the floor in Memorial Hall. The stone by stone survey works well with the GIS interface, where each tile can have an associated number of database fields. It would have been possible to have simply completed this work using AutoCAD and linking it to an Access database. However, this technique does not have the same capacity for analyses and queries of the data, nor does it have the ability to analyze spatial relationships. For example, if AutoCAD and Access had been used, it would not have been possible to look at the relationship of distance from water and the detachment of tiles. One of the greatest

strengths of using GIS in this application is the ability to add new fields to the database in order to document future repairs and alterations to the floor.

GIS can be recommended for conservation projects with some caveats. The learning curve for using GIS is quite high, and should be taken into consideration before implementing any projects.

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Figure 1.1 Memorial Hall, primary facade.

Figure 1.2 Modern map of Faimount Park. From www.mapquest.com.

Figure 1.3. General view of the floor of the Great Hall. Photograph by Author.

Figure 1.4. Failure of decorative plaster.

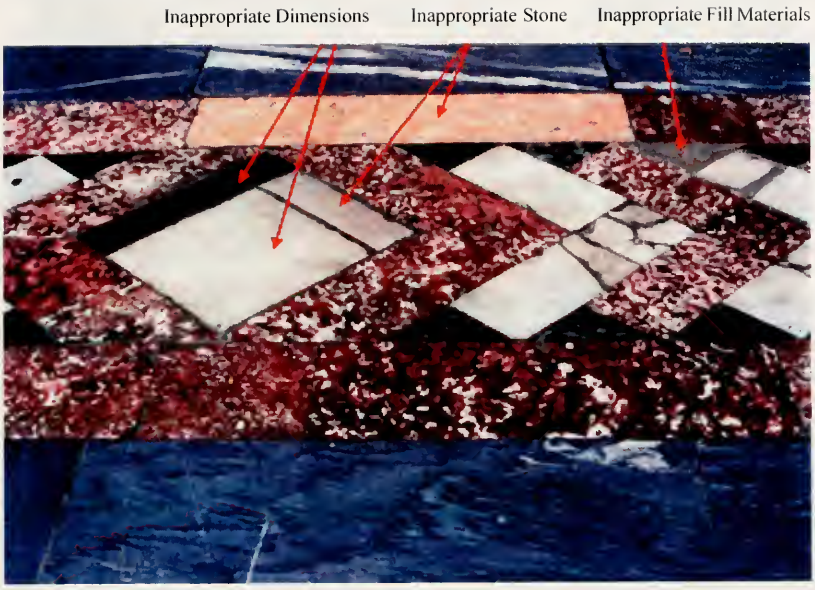


Figure 1.5. Figure showing different conditions. Photograph by Author.

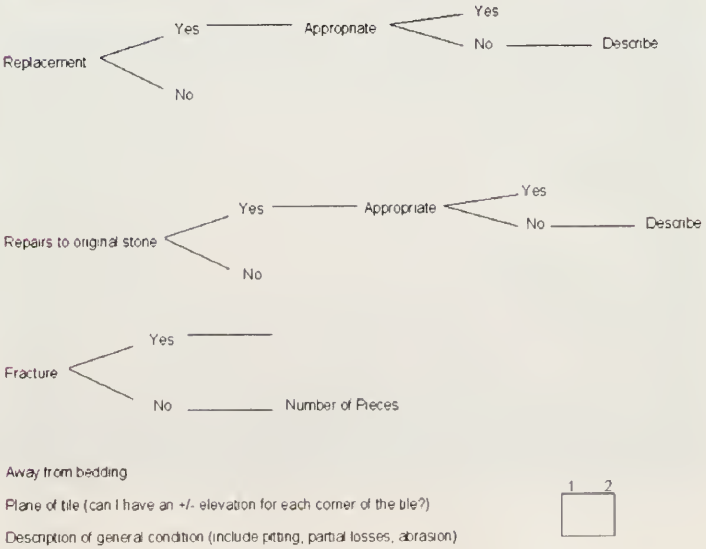


Figure 2.1. Flowchart illustrating the design theory of the survey form.

Figure 2.2. Inappropriate use of asphalt as replacement material. Photograph by Author.

Figure 2.3. Inappropriate stone type and dimensions. Photograph by Author.

Figure 2.4. More appropriate replacement. Photograph by author.

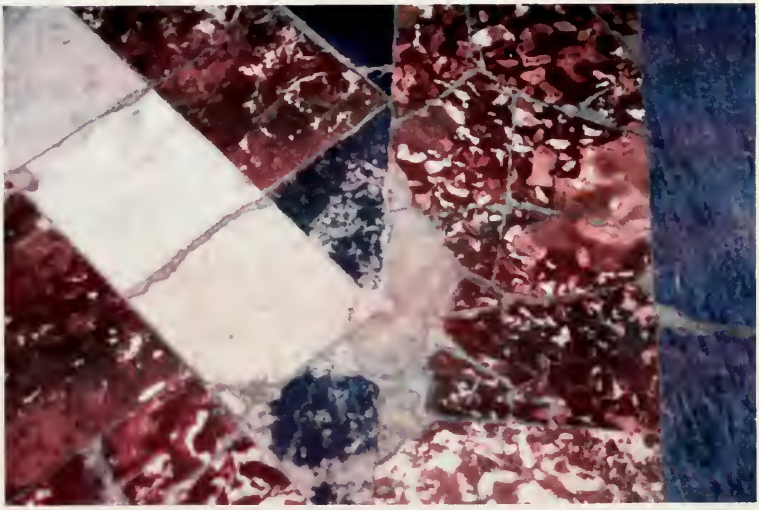


Figure 2.5. Inappropriate use of cement as a replacement material.

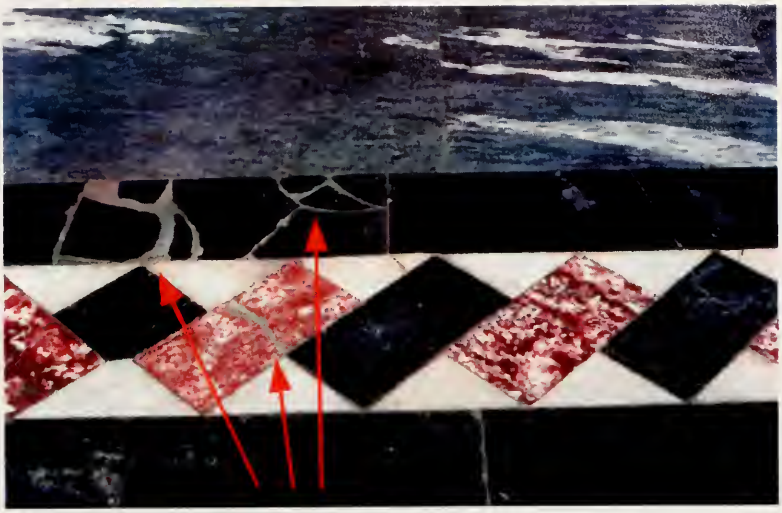


Figure 2.6. Inappropriate repair materials. Photograph by author.

Figure 2.7. Cracking. Photograph by author.

Figure 2.8. Tile out of plane. Photograph by author.

Figure 2.9. Exposed mortar bed that has failed. Photograph by author.

Figure 2.10. Exposed mortar bed that has failed. Photograph by author.

Figure 2.11. Partial loss. Photograph by author.

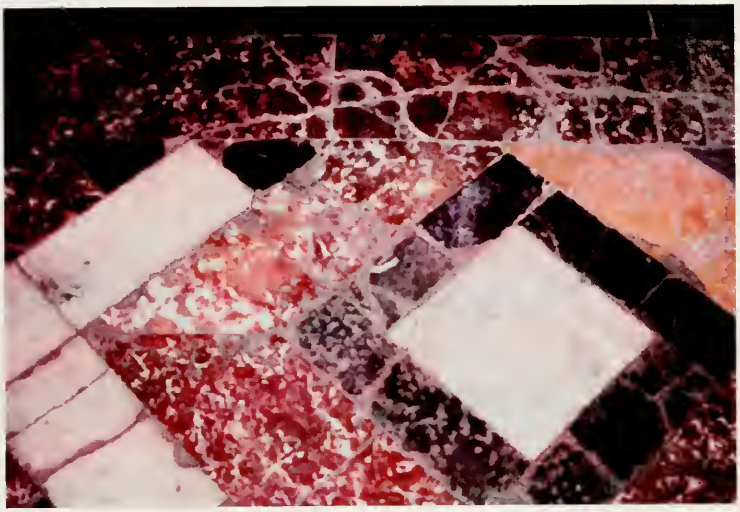


Figure 2.12. Severe pitting and cracking. Photograph by author.

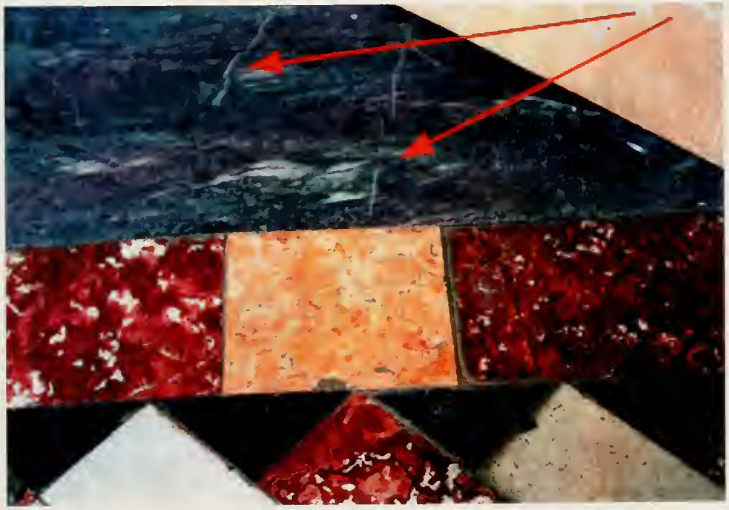


Figure 2.13. Abrasion indicated by arrows. Photograph by author.

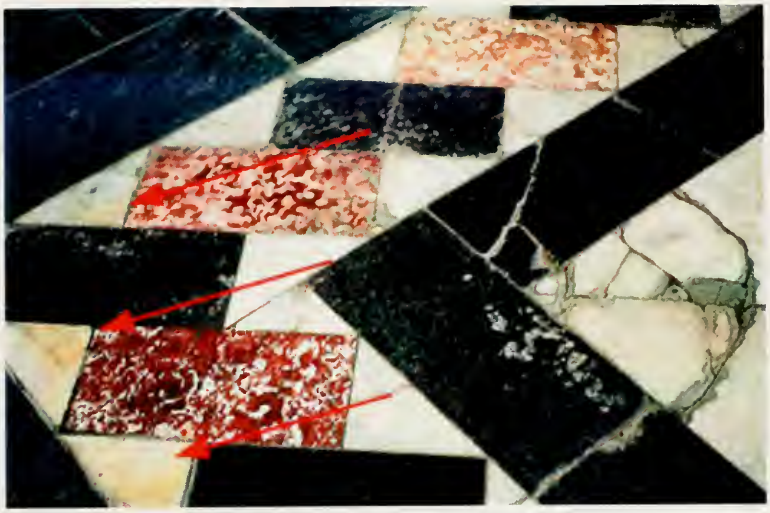
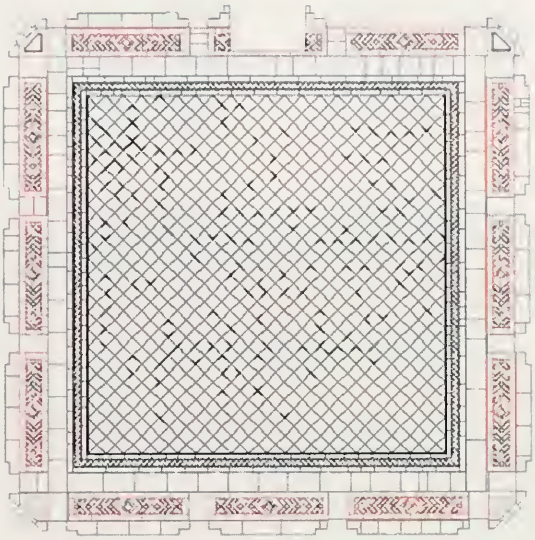


Figure 2.14. Discoloration of stone. Photograph by author.

Figure 2.15. Exposed mortar of visibly detached tile. Photograph by author.



2.16. AutoCAD Drawing

Result of Polyline to Polygon Script

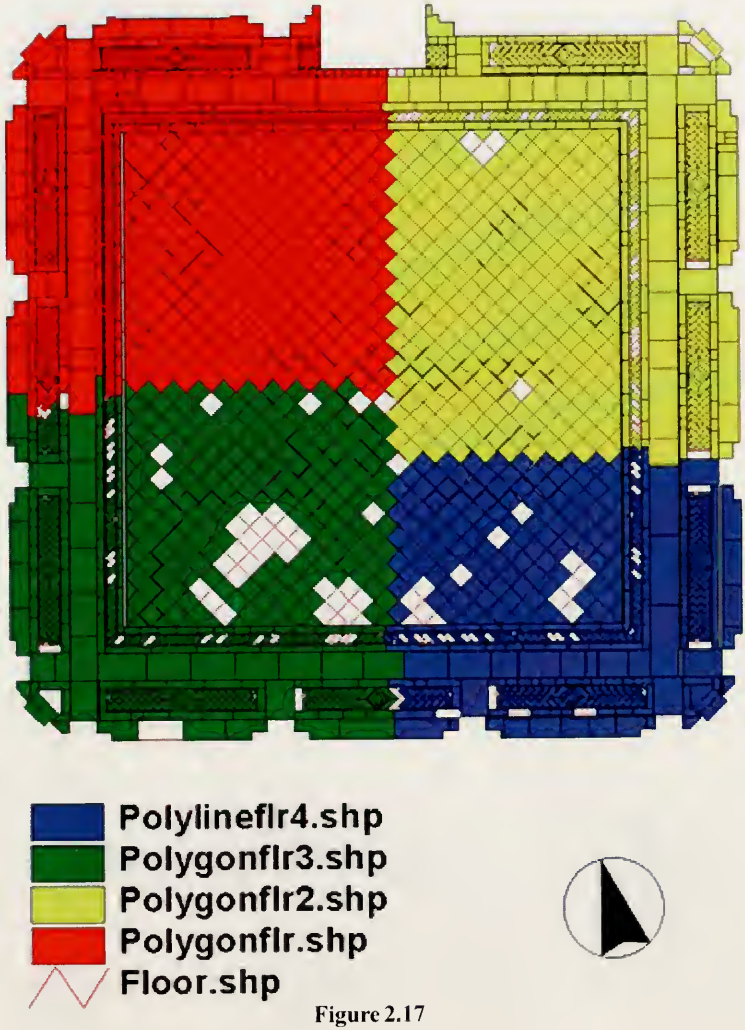
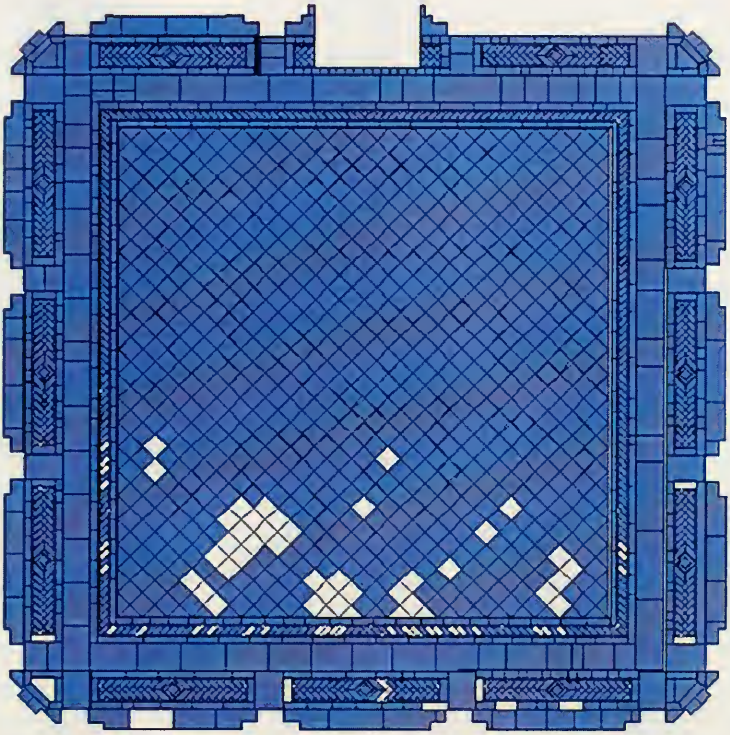


Figure 2.17

Partially Complete Polygon Theme



Floor.shp
Polygonfinal.shp

Figure 2.18

Figure 3.1. H.J. Schwarzmann, from McCabe (1975 reprint)

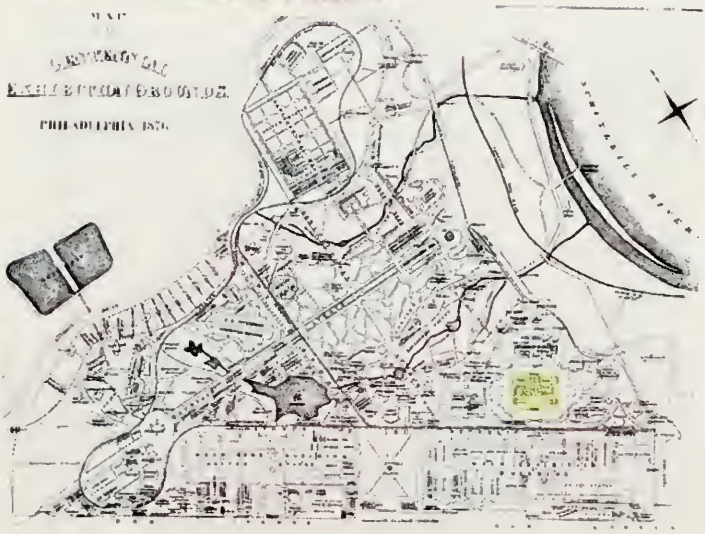


Figure 3.2 Centennial Map. Image from *Hand-book to the Centennial grounds and buildings...(1876)*

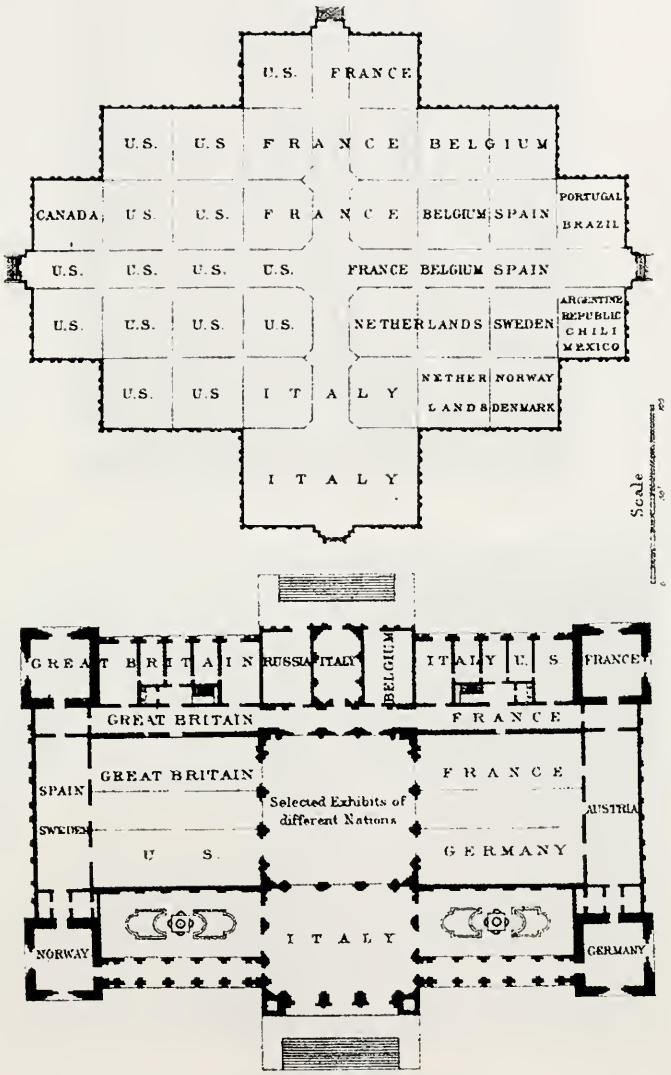


Figure 3.3. Original layout of gallery space.
From *US International Exhibition*, Vol. IX, 1880.

Figure 3.4. Right. Etching from Centennial Exhibition. From McCabe (1975 reprint)

Figure 3.5. Modern section of Memorial Hall. From Fairmount Park Commission Archives, Memorial Hall, Philadelphia, PA.

Figure 3.6. Image of the opening day of the Centennial Exhibition. From *Hand-book to the Centennial grounds and buildings...(1876)*

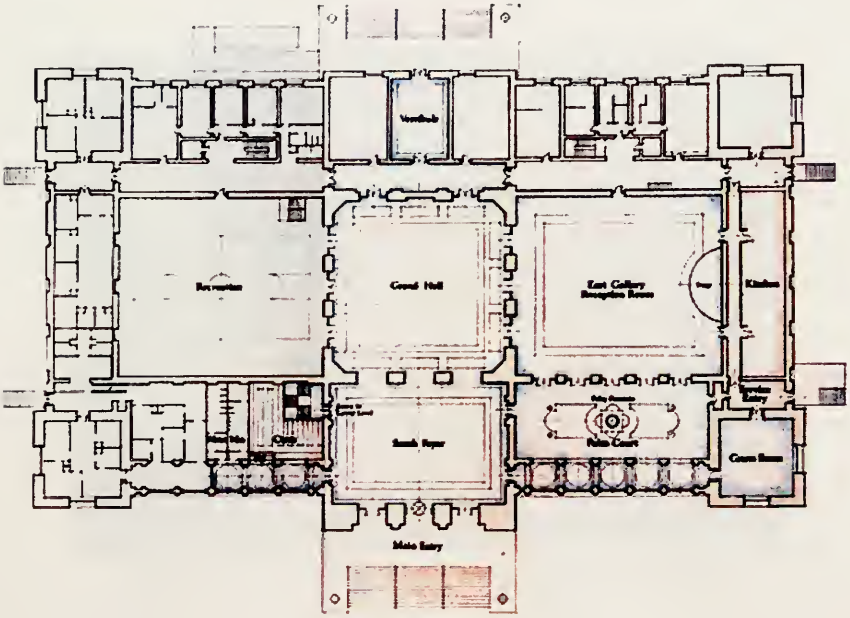


Figure 3.7 Plan from 1989 feasibility study. From Atkin Voith and Associates, 1988.

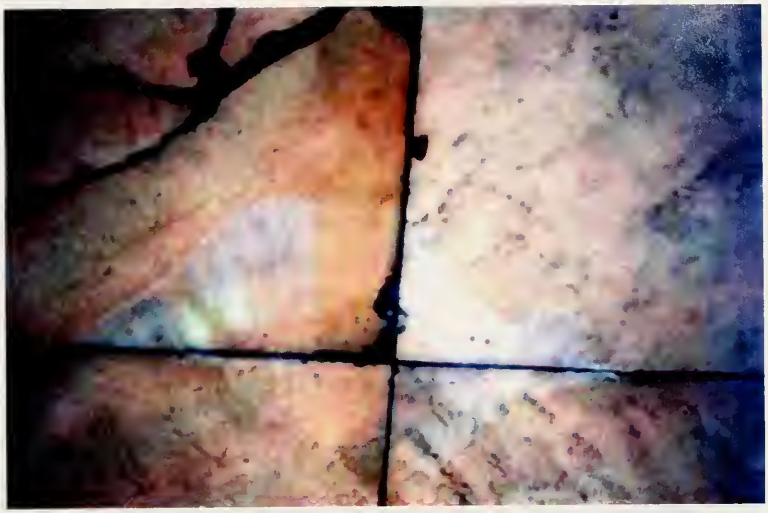


Figure 4.1. Water on floor, October 2000. Photograph by author.

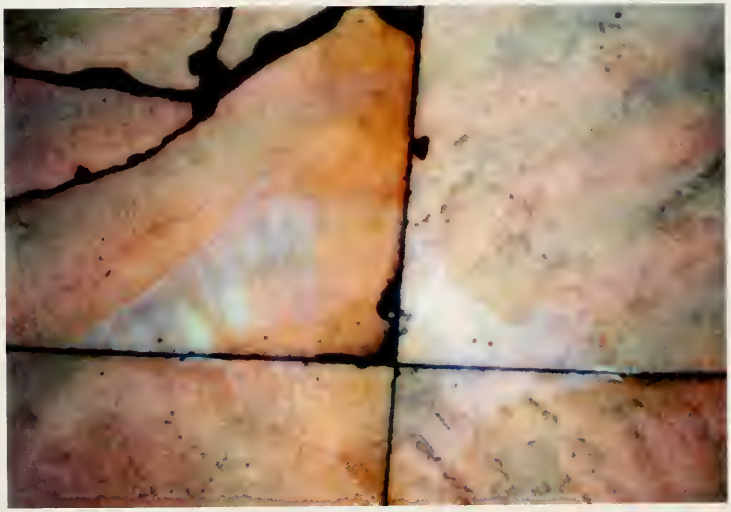


Figure 4.2. Water on floor, January 2001. Photograph by author.

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Water from rain 1/19/01
Polygonfinal.shp
Water.shp
48 0 48 Inches

Figure 4.3

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Distance from Water and
Visibly Detached Tiles
Polygon2.shp
Water.shp
VE_Mesh
0
1
2
No Data
Distance to Waterand
0 - 20.092
20.092 - 40.184
40.184 - 60.276
60.276 - 80.368
80.368 - 100.46
100.46 - 120.552
120.552 - 140.644
140.644 - 160.736
160.736 - 180.828
180.828 - 200.92
200.92 - 221.012
221.012 - 241.104
241.104 - 261.196
No Data
24 0 24 Inches

Figure 4.4

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Visibly Detached Tiles
Polygonfir2.shp
Vis_detch
Not Detached
Detached
Partially Detached
24 0 24 Inches

Figure 4.5

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Tiles That Sound Detached
Polygonflr2.shp
Snd_dtch
Not Detached
Detached
Partially Detached
No Data
24 0 24 Inches

Figure 4.6

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Presence of Past Repairs
Polygonflr2.shp
Repairs
No Past Repairs
Past Repairs
No Data
24 0 24 Inches

Figure 4.7

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Inappropriate Repairs
Polygon112.shp
Rpir_apr
Repairs Not Appropriate
Repairs Appropriate
Other
No Data
24 0 24 Inches

Figure 4.8

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Description of Inappropriate
Repairs
24 0 24 Inches
Polygon92.shp
Desc_tpl
general
Inappropriate Material
Improperly Reset
Inapp. Mat. & Improperly Reset
Mechanical Damage
No Desc

Figure 4.9

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Replacement and
Partial Replacement
Polygon1f2.shp
Replcmnt
Original Tiles
Complete Replacemnt
Partial Replacement
24 0 24 Inches

Figure 4.10

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Appropriate Replacements
Polygon2.shp
Repl_apr
Inappropriate Replacement
Appropriate Replacement
24 0 24 Inches

Figure 4.11

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Description of Inappropriate
Replacements
24 0 24 Inches

Figure 4.12

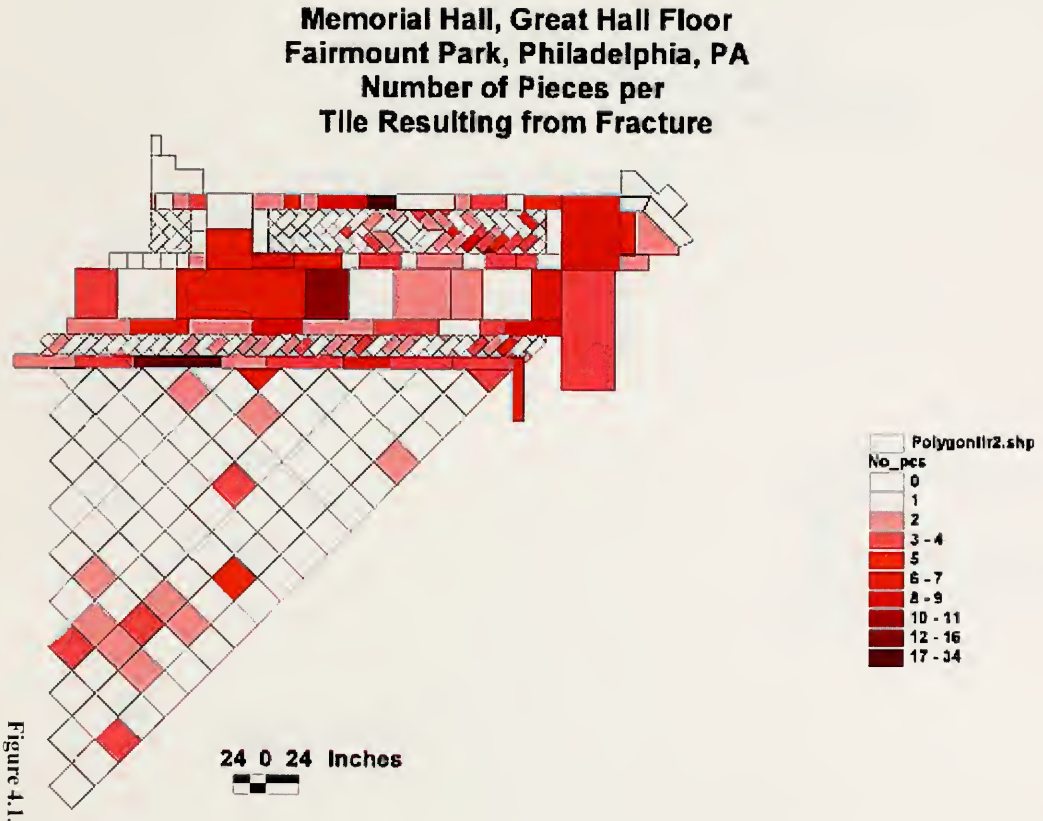

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Number of Pieces per
Tile Resulting from Fracture
Polygonlir2.shp
No_pcs
0
1
2
3 - 4
5
6 - 7
8 - 9
10 - 11
12 - 16
17 - 34
24 0 24 Inches

Figure 4.13

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Correlation Between Cracking and Tile Size
Polygonfit2.shp
larger than X, more than 3 pieces
False (0)
True (1)
No Data
smaller than X, more than 3 pieces
False (0)
True (1)
No Data
24 0 24 Inches

Figure 4.14

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Union of Cracking and Repairs
Polygonflr2.shp
repairs and cracking
False (0)
True (1)
No Data
24 0 24 Inches

Figure 4.15

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Number of Corners Above the
Plane of the Floor
Polygonflr2.shp
Corners Above
0
1
2
3
4
No Data
24 0 24 Inches

Figure 4.16

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Number of Corners Below the
Plane of the Floor
24 0 24 Inches
Polygonflr2.shp
#Corners Below
0
1
2
3
4
No Data

Figure 4.17

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Number of Corners Even with the
Plane of the Floor
Polygonflr2.shp
Corners Even
0
1
2
3
4
6
No Data
24 0 24 Inches

Figure 4.18

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Stone Type
Polygontlr2.shp
Stone
Pink Stone
Gray Marble
Black Marble
White Marble
No Data
24 0 24 Inches

Figure 4.19

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Percent Abraded
Polygonflr2.shp
%abrd
0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 - 58
59 - 68
69 - 78
79 - 88
89 - 98
24 0 24 Inches

Figure 4.20

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Rust Discoloration
Polygonflr2.shp
Rust Discoloration
Present
Not Present
Not Present
24 0 24 Inches

Figure 4.21

Memorial Hall, Great Hall Floor
Fairmount Park, Philadelphia, PA
Yellow Discoloration
Polygon112.shp
Yellowish Discoloration
Discoloration Not Present
Discoloration Present
Discoloration Not Present
Yellowish Discoloration
Discoloration Present
Discoloration Not Present
24 0 24 Inches

Figure 4.22

Appendix A

Identification #: _____
Recorder: _____
Date: _____
Original stone type:_____
Sketch:

INTEGRITY OF FABRIC
Is the current stone a replacement?
Yes No Partial ____ (% of total tile area)
Is the replacement appropriate? Yes No
If it is not appropriate, describe: _____
_____
_____
Are there repairs to original stone tile?
Yes No
If yes, are they appropriate? Yes No
If not appropriate, describe:
_____
_____

VISUAL INSPECTION:
Is the tile cracked? Yes No
If yes, how many pieces? _____
Indicate on sketch.

Number of corners above plane of floor_____
Number of corners even w/ plane of floor ___
Number of corners below plane of floor_____
Chipped of corners? Yes No
% of perimeter w/ chipping:
_____

Partial loss (% of area lost of original)
_____
Pitting (% of total area that is affected by pitting) ____
Describe: _____
_____
Abrasion (% of total area abraded) ____
Describe:_____
_____
_____
Discoloration (% of total area affected by discoloration)____
Describe: _____
_____
_____
Is the tile visibly detached from bedding mortar? Yes No Partial

Does the tile sound detached from bedding mortar? Yes No
Partial

Natural cracks and fissures inherent in the stone? Yes No
If yes, indicate on sketch.

TREATMENT RECOMMONDATIONS:_____
_____
_____
_____
_____

Notes:
_____
_____
_____

Appendix B

Identification #: _____
Recorder: _____
Date: _____
Original stone type:
1 - Pink
2 - Grey
3 - Black
4 - White

INTEGRITY OF FABRIC

Is the current stone a replacement?
Yes No Partial ____ (% of total tile area)
Is the replacement appropriate? Yes No
If it is not appropriate, describe:
1 - general
2 - Cementitous/asphalt & c.
3 - Inappropriate stone
4 - Inappropriate dimensions
5 - 3 & 4 (inapr stone & dimensions)

Are there repairs to original stone tile?
Yes No
If yes, are they appropriate? Yes No
If not appropriate, describe:

1 - general
2 - cementitious/asphalt pointing of cracks or patches
3 - reset above plane of floor
4 - 2 & 3 (above plane and inapr material)

VISUAL INSPECTION:

Is the tile cracked? Yes No
If yes, how many pieces? _____
Indicate on sketch.

Number of corners above plane of floor_____
Number of corners even w/ plane of floor ___
Number of corners below plane of floor_____

Chipped of corners? Yes No
% of perimeter w/ chipping: _____

Partial loss (% of area lost of original) _____

Pitting (% of total area that is affected by pitting) ____
Describe: :_____

_____

Abrasion (% of total area abraded) ____
Describe:_____
_____

Discoloration (% of total area affected by discoloration)____
Describe: **1** - yellowish
2 – orange

Is the tile visibly detached from bedding mortar?
Yes No Partial

Does the tile sound detached from bedding mortar? Yes No Partial

Natural cracks and fissures inherent in the stone?
Yes No
If yes, indicate on sketch.

TREATMENT RECOMMONDATIONS:

0 – Remove inappropriate bedding mortar
1 – Remove inappropriate (cementitious/asphalt) fills/pointing/patches
2 – Reset in sound bedding mortar
3 – Replace whole tile with appropriate pink stone
4 – Replace whole tile with appropriate black stone
5 – Replace whole tile with appropriate gray stone
6 – Replace whole tile with appropriate white stone
7 – Remove inappropriate stone
8 – Point cracks/patches with pink
9 – Point cracks/patches loss with black
10 – Point cracks/patches loss with gray
11 – Point cracks/patches loss with white
12 – Patch partial loss with pink stone
13 – Patch partial loss with black stone
14 – Patch partial loss with gray stone
15 – Patch partial loss with white stone
16 – Flip stone and polish
17 – Cut existing stone to proper dimensions
18 –
19 –

Appendix C

Original mortar stable condition (doesn't need to be replaced)

Original mortar unstable condition (needs to be removed and replaced)

Appropriate replacement mortar, stable condition (doesn't need to be replaced)

Appropriate replacement mortar, unstable condition (needs to be removed and replaced)

Inappropriate replacement mortar, stable condition (needs to be removed and replaced)

Inappropriate replacement mortar, unstable condition (needs to be removed and replaced)

Appendix D

Fire Insurance Survey (Transcribed Excerpts)

I have Surveyed a Granite Building for the Centennial Board of Finance in trust for the State of Pennsylvania as to Two thirds, and for the City of Philadelphia for one Third, Situate about 800 ft. East of Belmont Avenue and 800 ft North of Elm Avenue, Fairmount Park. The Building being 365 feet long by 210 feet deep with such angles and projections as per [plan]. The main features are the Entrance North through a semicircle arched doorway, 9 ft wide, 3 Entrances south each 15 ft wide and 40 ft high with semicircular arches, 4 Pavilions, 45 ft square, 2 Arcades on South front 40 ft long x [20] ft wide, connecting Pavilions with the Centre, 2 open Courts south 90 ft x 36 ft. The interior of Structure is divided into a South Vestibule 83 ft long by 60 ft wide, a north vestibule 27 ft 6 inches long by 39ft 3 inches wide, a Rotunda 83 ft square spanned by a Circular Dome, about 80 ft and 80 ft. high above [], 2 galleries 98 ft. long by 84 ft. wide, opening East and west into 2 Corridors 28 ft wide by 89 ft. long. A corridor on North side extending entire length of Building. 4 Piazzas, with Iron staircases in each. 12 Rooms opening from North Corridor. Walls are 6 ft. 3 ft. 2 ft.[] 18 inches and 12 inches thick. Outside walls granite [inside brick] Inside. Small Vestibule (South Front) 8 ft. x 10 ft, 10 ft. 6 inches high, octagonal 2 pair folding Sash doors, 4 lights 20 x [62]. 4 lights in Central wash, 12 x [26]. Top [sides ceiled wainscoating to doors] and sash. Stucco cornice, 6 inch architrave molded. Large Vestibule, 16 piers, 8 ft. 2 inches x 6" Pilasters are fluted with enriched capitals. Over each Pier are 2 Pilasters 1 – 2'2" x 6", 1 – 12" x 6" and 6 ft. high. Between the Pilaster and over Each Front doorway is a semicircular arched window, 3 lights each about 36 x 40. Plain molded Architraves with fancy key pieces. 4 girders of [channel] iron about 12 x 12 x [1x] transverse and longitudinal, spanning the entire space, 2 short parallel girders between the long ones and resting on each ot the Central Piers. 1 Centre of open iron work about 24" [inch?] diameter 2 windows 4 lights each 30 x 60, 64 each 8 x 8, 5 sectors each 15 inch Radius 1 Central semicircular arched light, 6 inch radious. 2 Pair folding Doors – moulded panels and wainscoating.

Rotunda. 3 semicircular arched openings 15 ft wide opening from vestibules. 3 similar opening on each side into East and west garden galleries and 2 on the North, 12 ft 6 inches wide opening into corridor. The arches spaces over these opening, except on South side, are closed. 16 piers, Central ones, 8 ft. wide x 4 ft. thick, side 6 x 6 inches x 4 ft. 2 Pilasters to each pier on South side, 1 – 4 ft. 6 "and 8 inches, 1 – 2 ft. x 6". 1 Pilaster to each Pier on north side, 5 ft x 6", and 2 to each E + W side, same as South front. One Corinthian Column 18 inches diameter, to each pier. Same no. of Parallal short and long Gardens as in Vestibule. An Iron arch 8 inches wide and 4 inches thick and about 5 ft rise resting against the wall on each side for entire length and width of Rotunda, assisting in supporting the Dome. The latter rises to a height of 80 ft. above the

Ceiling, about 80 ft. diameter with 63 semi-elliptic sash frames, 13 lights each, 226 x 12, and 1 – 8 x 12 or 883 lights in all. In each corner of Rotunda is an Alcove 18 inches deep x 42 " wide and about 7 ft. high with semicircular arched top. The Pilaster in Vestibules, Rotunda and Ex[10] Galleries rest on Pedestals; 4 ft. 10" x 9" and 3 ft. x 8" x 42 inches highs. Caps 8 inches white marble base 12 inches grey marble, Pedestals [Leisbon] marble, all highly polished. Cornices + moldings all highly enriched + of plaster. Keystones to arches 18 inches deep. Width of arches 18 inches.
...Galleries (East + West)...North Corridor...12 Rooms on North Side ...Water Closet 1 door into passage way on lobby. 1 double floding slat door into closet. 1 Transom over outer door, 2 Lights 15 x 24, one 4 lights over nine door 15 x 20. 1 Stationary white marble top wash stand in Ante Room. Marble splash pieces, colored ware bowl. Nickel plated spigot. Cold water. 1 sky Light 3 lights 34 ½ x 49 ½. Walnut Wainscoating to water clisets – 48 inches high. 4 bowls (2 on each side of closet) white ware. Walnut hinged lids. Valves. 1 sky light 4 lights 36" x 46" ground glass. The closets on Each side are similar except that there is but one seat and bowl. Stucco Cornice in Ante Room and Passage. All floors are of granite, flag and Pennsylvania Blue Stone. Walls and ceilings are [Rough Calcomniced]. Piazzas...2 Piazzas ... Water Closet and Urinals ...North Vestibule...Cellar. The Ceiling is composed of a series of circular Brick arches, 4 ft. wide, and iron girders, part running transversely and art longitudinally. 128 Iron pillars, 8 inches diameter, supporting 27 rolled Iron Double T Girders 12" x 5" 12 more Pillars used 6 Girders under north Rooms. Cellar Walls of Solid stone Blocks. Brick arch ways between Passages. A continuous circular brich arch under steps North and South front for wole length. 3 Girders 12 x 5 x 15 ft. between front piers, under entrance. 1 Grille[] at foot of stairway. 6 openings for light and air on South side, with inner and outer crating. 2 Coal Holes on E and W sides (1 on each) 5' high x 8' deep x 3'6" wide – grating outside. At each end of North steps is a double folding Grille 8 ft high arched top. Roof of Dome is of iron and glass...(describes the roofing system)... Cornices around base of Dome and Balconies are of Galvanized Iron...

Febry. 21st 1885 [Wm. W. Trapier]
For Surveyors

Conditioned to be occupied as an Art [Hall] and Gallery.
The following Amounts Insured by the following Companies allowed, and in case of [lofs] to be borne proportionately by ...(total insurance $120,000)

Appendix E

Mortar Characterization - Examination Phase

Site: Memorial Hall Floor		**Sample #** M1
Sample Location: See Map		
Removed by: **C. Miller**	**Examined by:** C. Miller	**Date:** 01/2001

Relevant facts about sample: Some white aggregate, some grey aggregate. White binder, extremely soft.

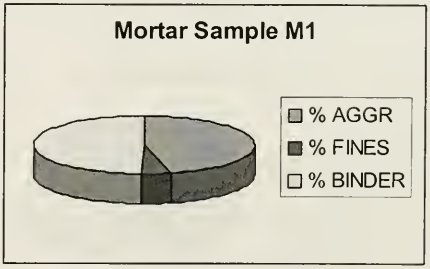
Observations of dissolved materials: Violent reaction with 1 M HCl

Percentage of sand: 46.2%
Percentage of fines: 4.2%
Percentage of dissolved binder: 49.7%

Appropriate Proportions for Replicate Mix:

Sieve Size	Grams Retained	% of Aggregate Retained
2.36 mm	0.00 g	0.0%
1.18 mm	0.03 g	0.7%
600 μ	0.10 g	2.5%
300 μ	1.38 g	33.8%
150 μ	2.32 g	56.9%
75 μ	0.21 g	5.1%
pan	0.04 g	.1%
Total	4.08	99

Interpretation/Comments:
Large concentration of mica and quartz. Particles are angular, not rounded. Appears to be of local origin. 0.03 g aggregate lost in sieving.



Mortar Characterization - Examination Phase

Site: Memorial Hall Floor		**Sample #** M2
Sample Location: See Map		
Removed by: **C. Miller**	**Examined by:** C. Miller	**Date:** 01/2001

Relevant facts about sample: Moderately hard sample with mostly grey aggregate. Some large white and orange aggregate. Difficult to break with mortar and pestle.

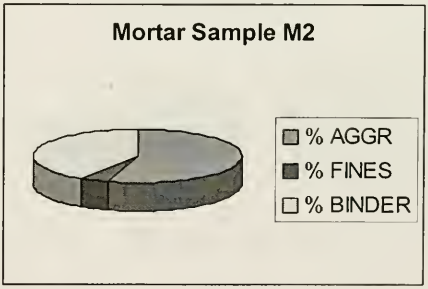
Observations of dissolved materials: Extremely violent reaction with 1 M HCl. Large white pieces were non-reactive to concentrate acid (14 M).

Percentage of sand: 54.3%
Percentage of fines: 4.8%
Percentage of dissolved binder: 40.8%

Appropriate Proportions for Replicate Mix:

Sieve Size	Grams Retained	% of Aggregate Retained
2.36 mm	0.48	8.8%
1.18 mm	0.34	6.3%
600 μ	0.53	9.7%
300 μ	2.65	48.7%
150 μ	1.29	23.7%
75 μ	0.15	2.7%
pan	0.00	0.00%
Total	5.44	99.9%

Interpretation/Comments:
Angular aggregate, presence of mica and quartz. Appears to be of local origin, but not river sand. 0.08 g of aggregate lost in sieving.



Mortar Characterization - Examination Phase

Site: Memorial Hall Floor		**Sample #** M3
Sample Location: See Map		
Removed by: **C. Miller**	**Examined by:** C. Miller	**Date:** 01/2001

Relevant facts about sample: Gray in color. Hard with large pieces of whitish aggregate. Difficult to grin with mortar and pestle.

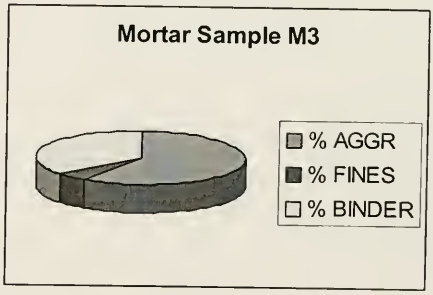
Observations of dissolved materials: Reaction with 1 M HCl was not violent.

Percentage of sand: 59.2%
Percentage of fines: 4.6%
Percentage of dissolved binder: 36.2%

Appropriate Proportions for Replicate Mix:

Sieve Size	Grams Retained	% of Aggregate Retained
2.36 mm	0.13g	2.9%
1.18 mm	0.07g	1.5%
600 μ	0.29g	6.4%
300 μ	2.47g	54.5%
150 μ	1.41g	31.1%
75 μ	0.13g	2.9%
pan	0.00g	0%
Total	4.53g	99.3%

Interpretation/Comments:
No mica present. More rounded particles, largely quartz. 0.09 g aggregate lost in sieving. Modern repair.



Mortar Characterization - Examination Phase

Site: Memorial Hall Floor		**Sample #** M4
Sample Location: See Map		
Removed by: **C. Miller**	**Examined by:** C. Miller	**Date:** 01/2001

Relevant facts about sample: Whitish binder with some gray, white and orange aggregate.

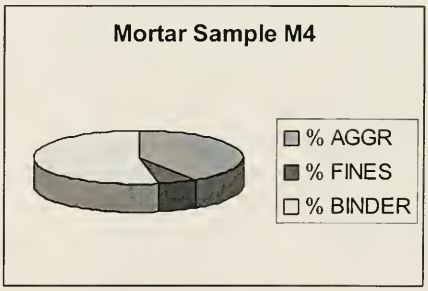
Observations of dissolved materials: Violent reaction with 1 M HCl.

Percentage of sand: 40.8%
Percentage of fines: 6.2
Percentage of dissolved binder: 53.0%

Appropriate Proportions for Replicate Mix:

Sieve Size	Grams Retained	% of Aggregate Retained
2.36 mm	0.00g	0%
1.18 mm	0.10g	3.3%
600 μ	0.20g	6.6%
300 μ	1.00g	32.8%
150 μ	1.45g	47.5%
75 μ	0.24g	7.9%
pan	0.06g	2.0%
Total	3.05g	100.1%

Interpretation/Comments: Mica and quartz in aggregate, angular particles. Probably of local origin, but not river sand.



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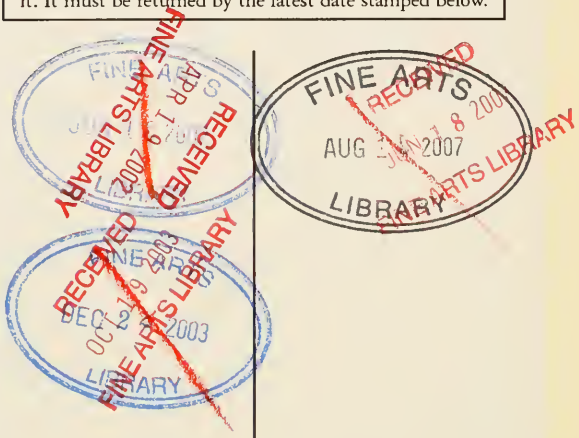

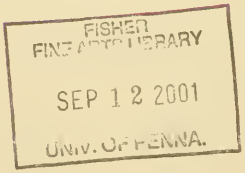

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